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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE GEOLOGICAL SURVEY
FRANK W. DeWOLF, Chief

Cooperative Mining Series

BULLETIN 25

GAS PURIFICATION IN THE MEDIUM-SIZE GAS PLANTS OF ILLINOIS

BY

W. A. DUNKLEY, State Geological Survey Division

and

C. E. BARNES, Engineering Experiment Station

ILLINOIS MINING INVESTIGATIONS

Prepared under a cooperative agreement between the Illinois State Geological Survey Division, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines

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GAS PURIFICATION IN THE MEDIUM-SIZE GAS PLANTS OF ILLINOIS

By W. A. Dunkley and C. E. Barnes

PURPOSE OF THE INVESTIGATION

For several years, the Illinois State Geological Survey Division, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines have been carrying on a cooperative investigation of coal and coal-mining methods in the central district, which includes the states of Illinois and Indiana, and the western end of Kentucky. One division of the main investigation is the use of coals of this district in gas manufacture. A number of bulletins have been published (see inside rear cover), dealing with various phases of this subject. Gas purification, the topic discussed in the present bulletin, is a phase of the subject which has an important bearing on the use of central district coals in gas manufacture with the existing equipment and operating methods.

One of the chief problems confronting the gas operator in using coals of the central district in place of gas coals from Pennsylvania, West Virginia, and eastern Kentucky, is the increased amount of sulphur which must be removed from the gas before distribution. This increase may be small or large, according to the particular coal used, but even the central district coals of lowest sulphur content usually contain more sulphur and yield more to the unpurified gas, whether coal-gas or water-gas, than do the best low-sulphur gas coals from the regions mentioned, or the cokes made from those coals.

Recognizing this condition, it was decided to make a study of existing purifying conditions in the gas plants in Illinois, to ascertain to what extent the use of low-sulphur central district coals would overload the purifying equipment now installed, and where changes in equipment, operating methods, or purifying materials might be necessary to enable the various plants to purify the gas from central district coals economically, should other conditions make a more extended use of these coals desirable.

INSPECTION OF GAS PLANTS

The problem of studying Illinois gas-purifying conditions was assigned to W. A. Dunkley, gas engineer of the State Geological Survey Division, and an inspection trip was made by him to sixteen gas plants. The plants visited comprised nearly all of the medium-size plants of the State, including the suburban plants of Chicago. The urban plants of Chicago were not studied at this time, since it was felt that on account of their large size and special conditions, they might have problems which were not typical of individual plants in smaller cities.

NATURE OF DATA COLLECTED

In visiting the various plants an effort was made to secure as detailed information as possible in the time available, regarding load factor, size and arrangement of equipment for cleaning and purifying the gas, gas storage capacity, fuels used, and purifying methods employed. A few simple tests were made in each plant to determine the sulphur content of the unpurified gas and the amount of tar entrained in the gas entering the purifiers. Samples of spent purifying material and unused material were collected wherever possible, in order that information to be gained from chemical analysis of these materials might supplement the information available from inspection of the plants and conversation with the operators. At all stages of the inspection, hearty cooperation was given by the gas men interviewed, and much interest was manifested by them.

With the opening of the college year, 1919-1920, at the University of Illinois, C. E. Barnes, research graduate assistant in gas engineering at the University, was assigned to assist Mr. Dunkley in this study. Mr. Barnes devoted most of his time to the analytical work involved in studying the purifying materials collected during the inspection of the various plants.

A summary of the results of these studies and a statement of the conclusions that seem warranted follow:

SUMMARY

To summarize briefly, the following purifying conditions were found to exist in the plants inspected:

1. Low-sulphur eastern gas coals were being used in practically all of the coal-gas plants inspected. These low-sulphur coals, together with the considerable percentages of water-gas made in most of the plants, gave an average H_2S content in the gas entering the purifiers of only 250 grains per 100 cubic feet.

2. Six of the eight straight water-gas plants inspected were using low-sulphur Illinois or Indiana coals for generator fuel. The average H_2S content in the unpurified gas in the water-gas plants was 140 grains per 100 cubic feet.

3. In spite of the generally low sulphur-content of the gas to be purified in all the plants, 75 per cent of the water-gas plants and 50 per

cent of the mixed-gas plants had maximum hourly gas productions in excess of purifier capacities. The computed overloads varied from 11.5 to 177 per cent.

4. Only two water-gas plants and one mixed-gas plant had average hourly productions in excess of purifying capacity.

5. Overload in most cases was due to lack of uniformity of load on the purifiers. This in turn was due to the sharp peak load and insufficient holder capacity. In some cases the load could probably have been materially reduced by a little more attention to the rate of pumping gas through the purifiers.

6. Tar in appreciable amounts was found in the gas entering the purifiers in nearly all the plants inspected. The spent oxide from all the plants contained some tar. The average tar content of spent oxides from water-gas plants was 6.9 per cent and from mixed-gas plants 3.6 per cent. Tar seemed to be chiefly responsible for low sulphur absorption in some cases.

7. The spent oxides from mixed-gas plants had an average sulphur content of 37.4 per cent, and those from straight water-gas plants had an average sulphur content of 21.7 per cent. Overload and tar seemed to be mainly responsible for these conditions in some cases. In other cases, operating methods seemed to be the cause of these low absorptions.

8. Revivification in place was practiced by most water-gas plants but by few mixed-gas plants at the time of inspection. Only one plant revivified oxide in the off-box. Little trouble was reported in that plant as a result of the practice, and the operating costs were low.

9. Though several purifying installations are arranged for reversible gas flow, there seems to be little effort to realize the fullest advantage from this arrangement. The same is true of rotation of boxes.

10. Few operators keep purifying records from which actual performance of a particular batch of oxide or method of operation can be definitely determined.

11. Few operators make any systematic quantitative tests on their purifiers to determine performance of the individual oxide batches. In several plants where the necessary testing apparatus is available, it is seldom used.

12. It seems that the greatest opportunity for immediate improvement in purifying conditions rests in the establishment of a simple but regular testing routine, together with better purification records. The analysis of fouled oxides for sulphur and tar, even if done by an outside laboratory, would, it is believed, be worth while.

13. Total purification costs for the year 1919 varied in the plants inspected from 0.5 cents to 2.25 cents per 1,000 cubic feet of gas purified. Careful operation and good facilities for the handling of oxide were apparently responsible for low costs in several cases where the equipment was overloaded. Different conditions prevailing in different plants preclude the possibility of drawing comparisons as to the effects of load, etc., on costs.

14. Few different oxides are used in the plants of the State. It is believed that more experimentation on the part of gas companies, to find materials best suited to particular conditions, would be advantageous.

15. The use of low-sulphur Illinois and Indiana coals as water-gas generator fuels is general in the water-gas plants of the State. Though the sulphur content of the resulting unpurified gas is in some cases double that of gas from low-sulphur eastern cokes, the computed capacities of the purifiers is but slightly less in the former case.

16. Low-sulphur Illinois coals in coal-gas manufacture might decrease computed purifier capacities by 25 per cent in some cases, as compared with the gas coals in use at the time of inspection. This decrease might be offset in a measure by more attention to selection of oxides, by making the load on the purifiers as uniform as possible, and by more attention to tar removal and purifying operation.

17. In several cases it appears that coals of higher sulphur content could be handled if existing equipment were rearranged and made more flexible in operation. In a few cases additional purifying apparatus is badly needed.

THE PURIFYING PROCESS

The purification of gas, by which in the narrower sense is meant the removal of the sulphur present in the form of hydrogen sulphide (H_2S), is accomplished by the same process in nearly all the gas plants of the United States. It was discovered about 35 years ago that hydrated oxide of iron was a much more economical absorbent for this sulphur compound than slaked lime which had been in use since the beginning of the gas industry.

Oxide of iron does not remove sulphur compounds other than H_2S present in the gas, but since the gas from most American coals does not usually contain any excessive amount of these other sulphur compounds, it followed that purification with hydrated oxide of iron was adopted almost universally within a few years after its initial use for this purpose. Hydrated oxide of iron, when of good quality, not only absorbs a large amount of hydrogen sulphides, but also, after sulphiding, if exposed to the action of the oxygen of the air, undergoes a process of regeneration whereby iron oxide is again formed by oxidation of a considerable portion of the iron sulphides present, free sulphur being liberated. This process is usually called revivification by gas operators. After revivification the material is again in condition to be used for purifying gas. Alternate sulphiding and revivification may be carried on until, with favorable conditions, the material may contain 50 to 60 per cent of sulphide. It is then usually incapable of absorbing more hydrogen sulphide on account of the clogging action of the free sulphur and the formation of more or less inert iron compounds and is replaced by new material.

The chemical reactions involved in the sulphiding and regenerating, or revivifying, processes are not known with absolute certainty. Various chemical equations have been written expressing the probable final reactions, but it is likely that many secondary reactions really take place which are decidedly more complex than those given in the text books. Since it is the intention to confine this bulletin to the practical working phases of the purifying process, no attempt will be made here to repeat these equations or to go deeply into the theory of the reactions. The reader is referred to the literature of gas manufacture and chemistry for existing information on this subject.

FACTORS AFFECTING PURIFICATION

Efficiency and economy in gas purification depend upon three main factors—equipment, operating methods, and purifying material. The effect of each of these factors is more or less determined by existing plant conditions. Perhaps the most important condition affecting plant conditions is the load factor. Load factor as applied to purification will here be designated as the relation between the volume of gas passing through the purifying equipment during the hour of maximum production and the rated hourly capacity of that equipment, as determined from its dimensions and from practical and theoretical considerations pertaining to operation with the usual purifying materials.

FORMULAS FOR GAS PURIFIERS

Since the advent of the gas industry, nearly 20 formulas have been propounded for the dimensioning of gas purifiers. Many of these were based upon the use of slaked lime, the predecessor of hydrated oxide of iron for purification. Many are indefinite in their terms and include an insufficient number of factors to make them really applicable to present conditions. The formula of the Steere Engineering Company[1] of Detroit, which appeared about a year ago, is perhaps the most complete of all, and while there are still factors which will probably have to be introduced or changed in it when our knowledge of these factors becomes more complete, the formula is very useful and has been used in the computations of this bulletin. For the convenience of readers, the Steere formula and some information regarding its use are given in Appendix A.

DESIGN OF EQUIPMENT

In designing purifying equipment for a given plant, a number of things must be considered. One of the most important is the output of the plant, both present and prospective. In spite of electric competition, the output of most gas plants is growing rapidly; in fact, many companies are experiencing difficulty in keeping up with the demand for gas. It is important, therefore, to make the purifying equipment of ample size, but at the same time the investment is heavy and the interest on a greatly oversized equipment may offset to a considerable extent the operating advantages which might be derived from extra large capacity.

LOAD FACTOR

Another factor to be considered is the distribution of load during the day. The rate of output of most plants is far from uniform. Indeed, it is not unusual for some plants to put out 10 per cent of their daily production during the hour of maximum load. And since storage capacity has not usually grown apace with output, it is frequently necessary to generate and purify the gas practically as fast as it is sent out. From the figures

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[1] Gas Age, Vol. 43, p. 227, 1919.

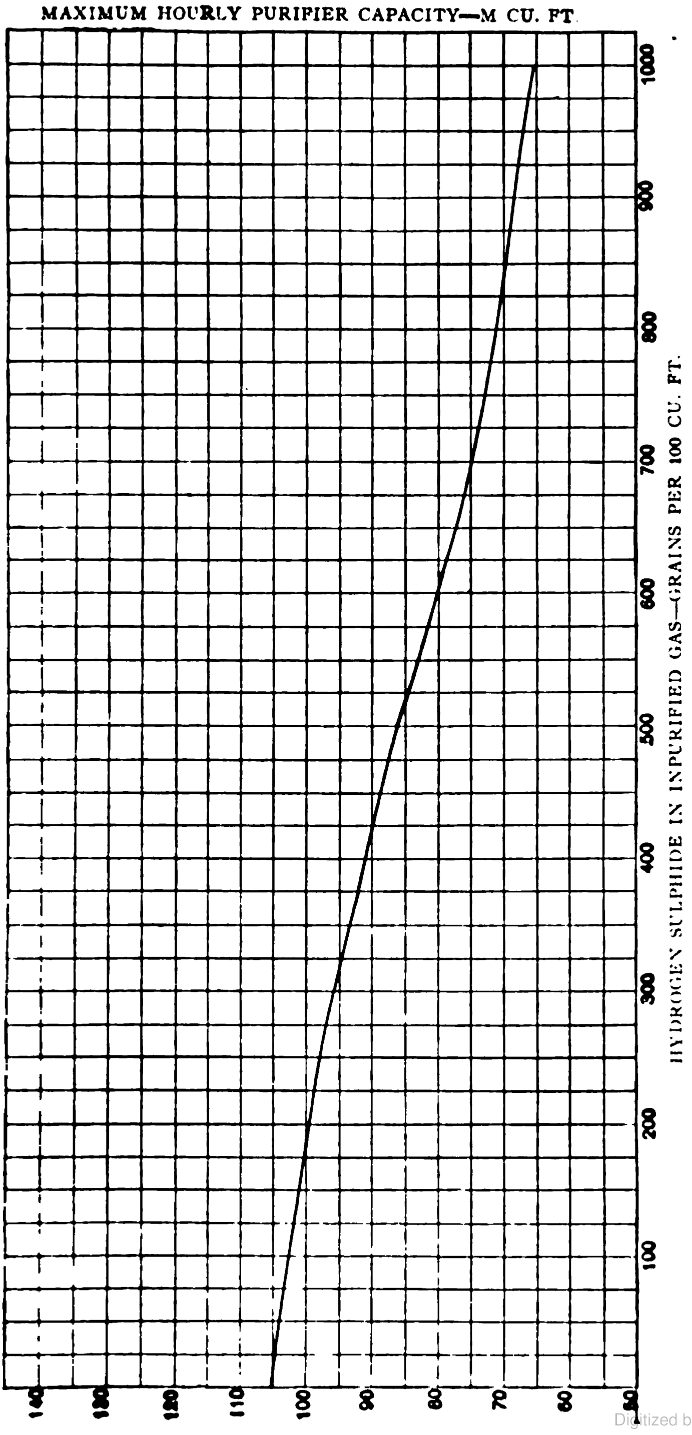

FIGURE 1.—Effect of hydrogen sulphide content of unpurified gas on purifier capacity, in a plant having purifiers rated at 100,000 cu. ft. hourly capacity with gas containing 200 grains of hydrogen sulphide per 100 cu. ft.

obtained from the inspection of 16 gas plants of Illinois, of which 8 made straight water-gas and 8 mixed coal- and water-gas, it was found that the maximum volume of gas purified per hour in water-gas plants varied from 4.5 per cent to 11.2 per cent of the maximum daily output, with an average of 7 per cent; and in mixed-gas plants from 3.6 per cent to 9.3 per cent, with an average of about 6 per cent. Since the complete absorption of hydrogen sulphide from the gas by iron oxide takes a measurable time, the purifiers must be so designed that even at maximum rate of flow there will be ample time of contact between gas and oxide, even when the oxide is partially sulphided and inactive. As the laws of nearly every state require that the gas leaving the gas plant must at all times be free from any appreciable amount of hydrogen sulphide, the gas manufacturer must comply with this requirement by whatever means he may. Oftentimes when the purifying equipment is heavily overloaded or fuels run considerably higher in sulphur content that usual, compliance with the law is difficult and costly.

As an economic matter, the purifiers must be so designed that they will hold enough oxide to completely purify the gas at the maximum rate of flow for a sufficient time so that it will not be necessary to handle the oxide too frequently. It is desirable that the oxide be allowed to remain in the purifiers long enough between revivifications so that it will absorb a reasonable amount of sulphur. The labor cost of handling oxide is one of the heaviest items of purification cost, and it is therefore desirable that an oxide take up a maximum amount of sulphur with the least cost of handling. This can be done by making the purifiers large enough, due consideration being given to investment charges.

SULPHUR CONTENT OF GAS

The sulphur content of the gas to be purified is another factor to be considered. The gas industry has always been a particular customer in the purchase of coal, and the sulphur content has always been an important specification where there was otherwise little choice between coals. Good gas coals heretofore have contained not exceeding one per cent of total sulphur, and frequently the content of sulphur has been only .5 or .6 of one per cent. The decrease in supply of such superfine coals has caused gas operators to look about for possible new supplies, but while the industry will probably have to be reasonably particular so long as present purifying methods are in use, it will probably be necessary to use coals of higher sulphur content than would heretofore have been considered expedient. In water-gas not only the sulphur content of the generator fuel, but also the sulphur in the enriching oil must be considered. Purifying equipment consequently will have to be designed with these matters in mind.

The maximum permissible rate of gas flow through a system of purifiers does not vary inversely as the hydrogen sulphide content of the gas to be purified. Figure 1, which is plotted from the Steere formula, shows the relation existing between maximum hourly rate of gas flow through the purifiers and the hydrogen sulphide content of the gas. The curve represents the maximum hourly purifying capacity with various contents of hydrogen sulphide of a plant which would have a capacity of 100,000 cubic feet of gas per hour, if the gas to be purified contained 200 grains of hydrogen sulphide per 100 cubic feet.[1] It will be noted that if the sulphur content is multiplied by 5, giving 1,000 grains per 100 cubic feet, the capacity is reduced from 100,000 cubic feet to 66,500 cubic feet. Capacity in this sense pertains, of course, to the hourly rate of gas flow permissible, not to the capacity of the oxide for absorbing H_2S. If the oxide in the purifiers could be completely fouled in either case, it is evident that five times as much gas containing 200 grains of H_2S could be purified. It is evident, therefore, that the permissible rate of gas flow through the purifiers is not directly proportional to the absorption capacity of the oxide nor inversely proportional to the sulphur content of the gas. The rate of the chemical reaction has an important bearing, but this is not taken directly into consideration in any existing formula for the design of purifiers, though it is indirectly allowed for in the Steere formula.

CAPACITY OF AUXILIARY EQUIPMENT

While the capacity of the oxide purifiers must be designed to handle the maximum hourly load, a properly designed system may fail to accomplish the complete purification of the gas because of conditions existing in other units of the gas-cleaning apparatus. Under favorable operating conditions, the purifiers are not usually called upon to handle all of the hydrogen sulphide that is originally present in the gas when generated. Water and tar vapor condensing from the gas in the condensers, and wash water in the scrubbers all remove a certain amount of H_2S from the gas. In coal-gas plants the ammonia present in the gas has a very important part in sulphur removal, since it combines directly with H_2S. There is not enough ammonia present to remove all the sulphur, but this incidental purification may remove as much as 20 per cent to 40 per cent of the H_2S present in the gas. If the condensing and scrubbing apparatus is under-

---

[1] It may be objected by some that when the gas contains no H_2S at all the capacity of the purifiers would be infinite and that there should be consequently a sharp rise in the curve. Practically, however, as soon as there is any appreciable amount of H_2S present in the gas, the time factor of the reaction between H_2S and hydrated oxide of iron comes into play, necessitating a very appreciable time of contact to purify the gas. It is often observed in practice that it is more difficult to remove the last 10 per cent of H_2S from the gas than the first 90 per cent, emphasizing the fact that the permissible rate of purification is not inversely proportional to the H_2S content of the gas.

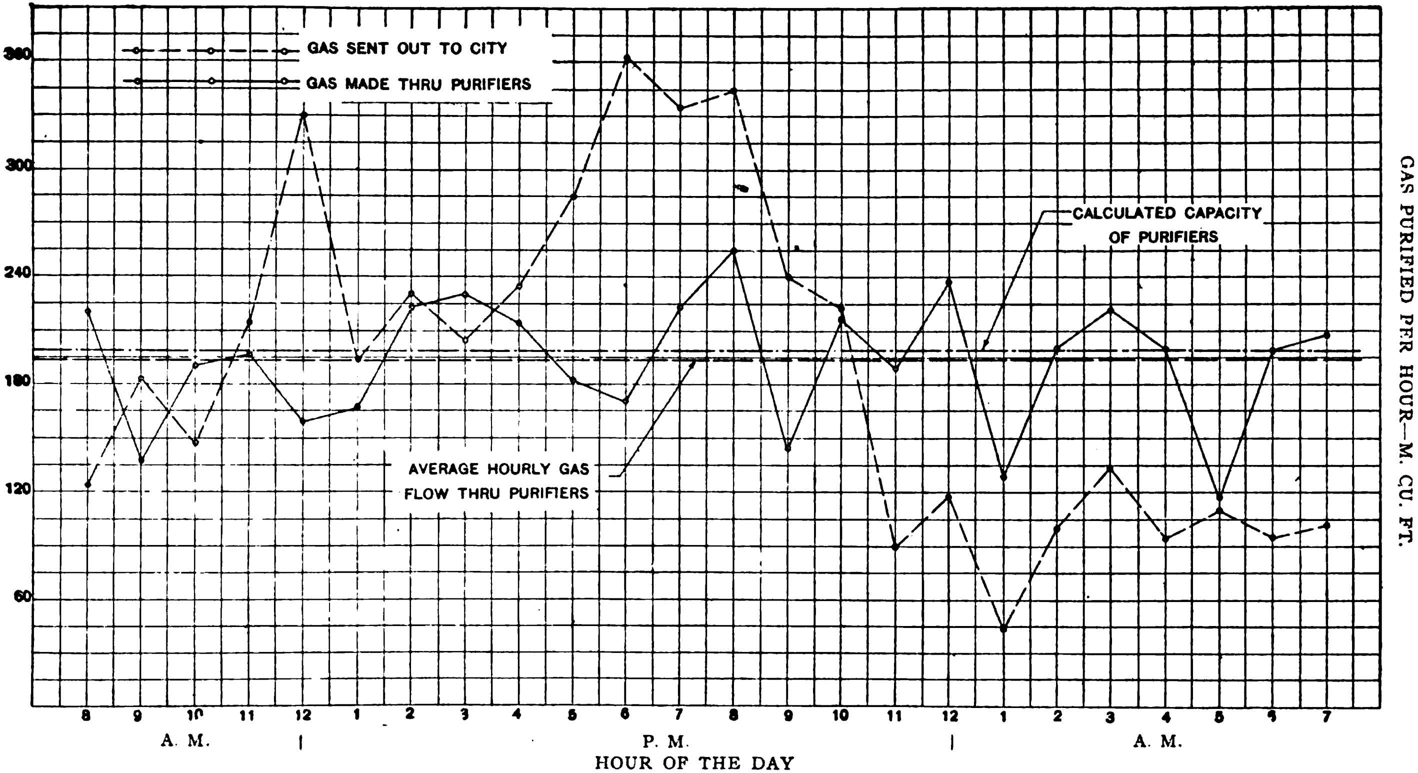

FIGURE 2—Distribution of load in a typical water-gas plant

sized, not only is this incidental purification diminished, but the oxide purifiers are forced to do part of the work, namely, tar extraction, which should be confined to the first-mentioned equipment. Tar and oil vapors undoubtedly have a detrimental effect on the operation of the purifiers, since they coat the purifying material and render it partly inactive. Despite the recognized harmful effect of these vapors, there are few plants in which the gas entering the purifiers is entirely free from them. In some plants well equipped as to purifier capacity this condition is responsible for poor purifying results. Tar removal before purification is very important both as a matter of equipment design and of operation, and deserves more attention than it usually gets. Some kind of test by which the tar content of the gas entering the purifiers can be determined, should be made regularly where purifying results indicate the possibility of this trouble. Frequently a plant which seems to need additional purifying capacity is really in far greater need of more efficient tar-extracting apparatus.

PURIFIER OPERATION

UNIFORMITY OF LOAD

Granted adequate purifying equipment, the purifying efficiencies realized will depend much upon how the equipment is operated. First, the handling of the load may well be considered. The hourly rate of gas output from a plant is, of course, out of the control of the gas manufacturer. He must supply the demand as needed. For the sake of safety to tide over any accident to the gas-producing equipment, it is usually considered necessary to keep the gas storage holders as nearly full as possible at all times. If the storage capacity is much undersize, in order to make good the output, it may be necessary to purify the gas almost at the rate of output during certain hours of the day. This may necessitate purifying the gas at a rate much in excess of the rated purifying capacity during such times. Even so, it may be possible by attention to smooth out the production curve somewhat. Figure 2 shows the output and production rates in a typical water-gas plant operating 24 hours per day. The rated capacity of the purifiers and the average hourly make are shown by horizontal lines. It will be noted that the hours of large production do not always coincide with the hours of large output. The production curve crosses and recrosses the line of average production not only when the production is near the average for a considerable time, but also when it is averaging considerably above or below the general average for some time. By careful attention to the rate of pumping gas these wide fluctuations could probably be prevented to a considerable extent with benefit to purifying operation.

TEMPERATURE CONTROL

Temperature control is another important consideration in purifier operation. Both excessively high and excessively low temperatures at the purifiers should be avoided. The statement is often made that at low temperatures (below about 60°F.) the sulphiding reaction becomes sluggish. That there is some difference of opinion relative to the effect of temperature on the purifying process, is indicated by the fact that this matter is now being studied by the Purification Committee of the American Gas Association. A temperature of about 100°F. is usually thought to give the best results, and often it is considered important that the temperature be kept up in winter by artificial means if necessary. Formerly it was the practice to have the purifiers installed indoors, but the high cost of building construction as well as successful experiments with outdoor purifiers have resulted in a rapidly increasing number of outdoor installations. Practically all of the new installations are of the latter type. Where the temperature of the gas has a tendency to fall in winter much below the temperatures above stated, it can usually be kept up by the installation of steam coils in the purifiers or by injection of steam into the gas ahead of the purifiers. The latter practice may be questioned by some operators on account of the amount of moisture which is deposited in the purifying material, while the former may be open to objection on the ground that it dries out the oxide too much. Some outdoor installations are insulated to diminish the drop in temperature during cold weather, but this is not common practice, at least in Illinois.

While a fairly high temperature is usually considered advantageous in its effect on the sulphiding reaction, the temperature of the gas throughout the condensing and purifying system should not be maintained too high, lest difficulty be experienced in extracting the tar. A temperature much above 100° at the inlet to the purifiers, if maintained by the original heat in the gas as generated, would usually necessitate a temperature considerably in excess of this back at the tar-extracting equipment. It is usually considered that 100° to 110°F. is about the highest temperature at which tar can be extracted efficiently by most forms of tar extractors, though opinion may vary on this point. During the inspection trip to various Illinois plants by the writer, several cases were observed where the temperature at the inlet of the purifiers was around 120° to 130°, but in practically every such instance there was an excessive amount of tar being carried into the purifiers. Probably the best results will be obtained by maintaining a temperature of 90° to 100°F. at the boxes and keeping the gas saturated with water by the admission of steam to the gas, or otherwise.

REVIVIFICATION

OUTDOOR REVIVIFICATION

As previously mentioned, the greatest advantage of hydrated oxide of iron as an absorbent for hydrogen sulphide lies in its ability to revivify or regenerate when after sulphiding it is exposed to the oxygen of the air. Naturally the first method of revivification adopted was to remove the sulphided material from the purifying box and expose it to the air. The appearance of the material as it changes from the black iron sulphide to red or brown iron oxide, is of course a guide to the operator by which he can determine with more or less certainty when the material is reoxidized and ready for use in the purifiers again. The usual procedure in revivifying out of doors is to put the material in piles or windrows, perhaps two or three feet high. When the material begins to heat as a result of the oxidation process, it is raked down into a layer a foot or so in thickness, and as the surface reddens, the whole mass is turned over by shovel, this operation being repeated until the mass is of uniform color and no longer heats. This process, simple as it seems, requires considerable attention. The material frequently oxidizes very rapidly upon removal from the purifiers, and when it contains a considerable percentage of iron sulphide it is likely to ignite, especially if in a deep mass from which heat cannot escape readily. Overheating is detrimental to the further value of the material, rendering it inactive. At the same time, a moderate degree of heat promotes the oxidizing reaction without injuring the material. The operator therefore usually cools hot spots in the material by shoveling them out and exposing the hot material to the open air, which rapidly cools it, rather than by application of water, which cools the material to such an extent as to unduly retard the revivification.

This method of revivification involves much handling of the material. Indeed, since it is not possible to leave material in the boxes until it is completely sulphided, it is usually necessary to handle it a dozen times or more to get a very good sulphide content. But since the sulphiding and revivifying reactions slow down greatly after a time, the cost of handling the material may soon offset the value of the work it is doing. Consequently, material is frequently discarded long before it contains 50 to 60 per cent sulphur, which is considered good operation.

REVIVIFICATION IN PLACE

Naturally gas operators looked for a method of revivifying which involved less handling of oxide, and revivification in place was the outcome. Two methods are in use at the present time, namely, (1) introduction of a small percentage of air (1 to 2 per cent) into the gas ahead of the purifiers; (2) blowing or drawing air through a box of material which has been shut off from the remainder of the purifying system. Each of these methods of revivification has its advantages and disadvantages, and there are some details of operation in both cases on which operators disagree.

SMALL PERCENTAGE OF AIR WITH THE GAS

One advantage of the first method is that it involves no danger and requires little attention. The air pump is connected to the exhauster and pumps more or less air as the exhauster runs faster or slower. One obvious disadvantage of the first method is the amount of inert nitrogen which is introduced into the gas, if an attempt is made to introduce enough air to secure complete revivification in place. Although less than 0.5 per cent of air would theoretically be required to accomplish the revivification of an oxide which was being fouled with gas containing, say, 100 grains of H_2S per 100 cubic feet, as a matter of fact, even 2 per cent does not completely accomplish revivification. Excessive nitrogen of course dilutes the gas and requires additional enrichment, especially if the gas is made to conform to a candle-power standard. With the heating-value standard which is fortunately rapidly replacing the candle-power standard, this effect is not so serious. The differences in operation found in different plants with this method of revivification relate chiefly to the reversal of direction of gas flow and order of the purifiers with respect to the condition of the contained materials. These will be discussed in the next section.

AIR BLOWN THROUGH OXIDE IN AN OFF-BOX

Revivification by forcing air through a box of oxide after shutting off the gas has been employed in various plants for a number of years and is heartily approved by many operators, and as heartily condemned by others. Its advantage lies in the fact that no nitrogen is admitted to the gas. On the other hand, careful attention has to be given to it while in progress, and under some circumstances it may be dangerous. O. B. Evans[1] of Philadelphia presented a paper before the American Gas Association recently, in which the experiences of several companies in the use of this method are given. From these experiences he concludes that revivification by this method is a simple operation when purifying capacity is ample and revivifications are frequent, but with overloaded purifiers extreme care must be used to prevent firing of the oxide. He believes that the best method is to recirculate air (which soon becomes chiefly nitrogen, since the oxygen is soon removed by the purifying material) continuously through the box and through a cooler of the contact type, in which it comes in contact with water. The water keeps the recirculated mixture saturated, and the water vapor helps to keep down the temperature in the oxide. Arrangement of valves is made whereby a small amount of fresh air can be admitted to the circulation and a similar amount of inert gas expelled from it as desired. The blower should be of sufficient capacity to reduce channeling effect and to circulate the mixture faster than the rate at which gas is passed through the box during operation. He states that shallow boxes aid considerably in successful revivification in place on account of their greater radiating capacity per bushel of oxide. With these methods Mr. Evans believes that revivification can be carried out without danger, channeling and excessive local heating being largely avoided. The successful experiences of many operators over a number of years confirm this.

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[1] O. B. Evans, Revivification in place, presented at a meeting of the Amer. Gas Assn., October, 1919.

REVERSAL OF GAS FLOW AND ROTATION OF BOXES

Reversal of direction of gas flow through the purifiers and the order of the various purifiers with respect to the condition of the contained oxide, are matters of considerable importance in connection with revivification in place. In both of these matters the operator may be limited by the arrangement of his equipment. Not all plants are so arranged that the direction of gas flow in a given box can be reversed; and while a certain amount of latitude is usually allowed as to the order of purifying boxes, one finds a number of cases where the connections are so arranged that the possible number of combinations is small. Obviously, any group of purifiers must be so connected that any box can be shut off for refilling. In most of the older installations, when one box is off, the order of the other boxes is predetermined, only one arrangement being possible. Reversal and rotation, as applied to revivification in place, depend upon the principle pointed out several years ago by B. E. Chollar, that iron sulphide will not revivify to the oxide in the presence of hydrogen sulphide. Let us assume, as is frequently the case in new purifier installations, that the gas enters at the middle of the box and passes downward and upward through the two layers of oxide and comes out at the top and bottom of the box. The lower layer will sulphide downward and the upper layer upward. If when the sulphiding has extended say half-way through each layer, the direction of flow be reversed so that the gas enters at the top and bottom of the box and leaves at the middle, then the comparatively fresh oxide in the top of the upper layer and the bottom of the lower layer will remove the H_2S from the gas, and any oxygen present will go on and revivify the foul upper part of the lower layer and the lower part of the upper layer. The frequency of reversals will depend upon the degree of loading of the purifiers. Where the purifiers are being operated at normal capacity, reversal once a week is often advised. With an overload, it might be advisable to to reverse oftener.

Box rotation is another means to accomplish the same end. Where there are three or more boxes in series, it would seem logical to have the clean box first to remove the H_2S and the fouler boxes after, to be revivified by the oxygen which had been admitted to the gas. The following are suggested orders of rotation of a 4-box set, the changes being made when H_2S appears at the outlet of the third box:

1 — 2 — 3 — 4
4 — 1 — 2 — 3
3 — 4 — 1 — 2
2 — 3 — 4 — 1

In this way the most revivified batch is placed first and the next cleanest batch is always last to take up any traces of H_2S which may get by the previous batches at any time.

Where there are only two boxes in series, especially those of the non-reversing type, it would hardly seem advisable to have the clean box first, since failure of the second box to revivify for any reason would leave no active material to intercept traces of hydrogen sulphide.

As stated earlier in this section, there is no method of procedure in the matter of revivification in place, which is accepted as best practice by all operators. The only way by which any operator may arrive at a satisfactory conclusion is to try various methods and arrangements and satisfy himself which method is most applicable to his particular plant.

CHEMICAL CONTROL AND RECORDS

In order to secure and maintain good purifying efficiencies, it is important that the operator know at all times the status of the material in each one of his purifiers. Knowing this, he will not only be able to judge whether his method of operation is satisfactory, but he will be able to detect differences in purifying material which might otherwise be obscured by other conditions. The extent of the system of tests and records maintained will of course depend, among other things, upon size of the plant and the force available. Practically every plant makes the simple lead acetate paper test, but this is merely qualitative. It tells of the presence or absence of hydrogen sulphide, but gives little information relative to the amount present. The total-sulphur test carried on under the requirements of the Public Utilities Commission, at least in the State of Illinois, gives information only with respect to the amount of sulphur in all forms present in the finshed gas, but gives no information in regard to the performance of the individual purifiers.

The introduction several years ago of the Tutwiler hydrogen sulphide burette marked a distinct advance in the matter of checking up purifier operation because it gave the gas operator a simple, easy method of studying his purifier performance without the aid of a trained chemist. Unfortunately, the apparatus has to be made of glass, and is so shaped and proportioned that it is easily broken; and, further, unless care is taken to remove the plugs of the glass stop-cocks and insert pieces of paper around them after using, they are very liable to become hopelessly stuck in a short time. Nevertheless, with reasonable care the apparatus can be kept in good order, and the information obtained with it is very useful. One advantage of the instrument is the short time required to make a series of determinations. Probably after a very little practice any operator, even with no chemical training whatsoever, could make a test of the gas entering the first box and leaving each box of a four-box series, in fifteen or twenty minutes. By simple subtraction of the number of grains of hydrogen sulphide found at the outlet of each box from the amount present at the inlet the amount of sulphur being removed by each box would be immediately known. The results of a test on a certain day might be as follows:

		H_2S Removed
Grains H_2S before boxes	100	
" " after 1st box	25	75 by 1st box
" " " 2d "	10	15 " 2d "
" " " 3d "	5	5 " 3d "
" " " 4th "	0	5 " 4th "

Now 5 grains of H_2S after the third box could probably be detected by lead acetate paper as ordinarily used and would perhaps ordinarily be taken as a sign to change the order or empty a box, but if this same distribution of the work continued for several days and the last box handled the remaining few grains of H_2S were absorbed in the last box all right it might be well to retain this order for a time, since a larger absorption in the first box would be accumulating. A considerably greater sulphur absorption might be realized in the first box than would be obtained if it were emptied or reversed as soon as a trace, as shown by lead acetate paper, was visible at the outlet of the third box. Steere[1] states that 20 to 50 grains of H_2S may be safely passed to the last box if tests are made regularly, and the boxes are properly proportioned. He would allow 20 additional grains to pass to the last regular box, where a catch box is provided. On the other hand, let us assume that the following results were shown by the tests:

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[1] Bull 37, Steere Engineering Co., 1919.

		H_2S Removed
Grains H_2S before boxes	100	
" " " 1st box	80	20 by 1st box
" " " 2d "	20	60 " 2d "
" " " 3d "	5	15 " 3d "
" " " 4th "	0	5 " 4th "

It would at once be evident that box No. 1 was not doing its share of the work, since if it were in good condition it could usually be expected to do at least 60 per cent of the total absorption. It would be evident that box No. 2 was bearing the chief burden and it would be high time to empty No. 1 or reverse so that it would clear up.

If such tests as the above were made faithfully day after day and carefully recorded in a book (not on loose scraps of paper) it is evident that a running record could be maintained from which, knowing the amount of gas metered per day, the actual number of grains of H_2S absorbed by each box from change to change would be known. Knowing the number of bushels of oxide in each box, the volume of gas passing in a given time, and the number of grains of H_2S absorbed by each box per 100 cubic feet of gas passing through, it would be very simple to calculate with a reasonable degree of accuracy the number of pounds of sulphur absorbed per bushel. A sample record and computation is given in Appendix B. Such results would be of far greater value in determining relative merits of various operating methods or of various oxides than would the usual record of gas purified per bushel between changes, because unless tests are made there is no way of knowing what proportion of the purification should be credited to each box. Usually the first box is credited with all of the purification on the theory that in the long run each box will be similarly credited, and will average up, but during this same time the sulphur content of the gas may change, or more or less tar may be carried forward, affecting sulphur absorption so that the actual performance may be entirely obscured by other conditions.

As a final check on operation, analysis of the oxide for suphur and tar after each removal from the box and especially before discard would be very helpful. Often a batch of oxide is discarded when it is still capable of doing much useful work, and perhaps even more often a batch is returned to the box at considerable expense of handling when it might better have been discarded. Even the trained eye may sometimes be deceived in judging oxide, especially if it contains some tar. In a paper by Fulweiler and Kunberger[1] a method for determining mathematically whether a given batch of oxide is worth using again has been developed. The formula used is given in Appendix C. It will be observed that no knowledge of higher mathematics is required, though one does need to know what the batch has done in the past and what it is capable of doing as judged by a simple laboratory test. If the operator were in possession of the facts derived from the running record of tests above described, together with certain costs which he should know for intelligent operation of his plant, it would not be difficult to use the formula provided he could make or have made an analysis of his oxide and a laboratory hydrogen sulphide absorption test.

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[1] Some of the Physical Characteristics of Ferric Oxide, Proc., Amer. Gas Institute, 1913, Vol. 8, Pt. 1, p. 476.

The writers of this paper do not advise every gas company large and small, to maintain a chemical laboratory and a trained chemist. The small companies probably could not afford these refinements. The large companies already have them and know their value. We will not attempt to prescribe the minimum size of plant that can afford a laboratory. However, many of the smaller plants in this and other states are links in a chain of plants. It would seem feasible for a chain of several plants to maintain a laboratory and a chemist, to whom samples of oxide, ammonia, and other materials could be sent for examination. The results reported by him from testing oxides, together with the Tutwiler test made by the plant superintendent or other person, and adequate record of purifier changes and batch performance, all taken together, would suffice to put purifying operation on a much higher plane than it now is in the average plant. It is believed that it would also effect a real economy in dollars and cents within a reasonable time.

Purification costs heretofore have usually been but a small item in the total cost of making and distributing gas, but with the greatly increased cost of labor, it is becoming especially desirable to get the greatest absorption of sulphur with the least amount of handling. Revivification in place, with its obvious advantages where properly conducted, should become much more general. If difficulties are encountered, careful inquiries should be made as to why they are encountered. Only by intelligent study, aided by tests and good records, can the best results be obtained.

QUALITY OF OXIDE FOR GAS PURIFICATION

The quality of oxide used for purifying gas is another factor affecting efficiency and economy of purification, but this has not as yet been worked out so that it can be expressed mathematically in computing performance of a given equipment. Some research work, having as its object the determination of the effects of the peculiar properties of various oxides is now in progress, and it is hoped to throw some light on the subject in a later publication. At the present time it is recognized that oxides produced by different processes, and indeed even oxides made by the same process, show variations in performance, but just what are the causes of these variations and how they can be controlled is not now known.

TYPES OF HYDRATED IRON OXIDES

Three main types of hydrated oxide of iron are in use for purification. These include:

(1) Oxides made by rusting case iron borings in the air with water only, or with accelerating agents such as sulphate of iron, salt, etc.

(2) Natural oxides, which include certain ores having the proper chemical and physical condition.

(3) Precipitated oxides, made by the chemical precipitation of hydrated oxides of iron from the salts of iron produced as by-products in certain industries or from the iron-bearing water of some mines.

Each of these oxides has properties peculiar to itself, the reasons for which are not yet clear. While ferric oxide (Fe_2O_3) is included in the composition of each and is the reacting material, the presence of other materials in combination with it and the physical structure of the material are of the greatest importance in determining performance. Ferric oxide by itself without water of hydration is almost or entirely non-reactive with hydrogen sulphide.

Formerly the iron content of a commercial material was considered as an index to its value for purifying gas. While this may be true to a limited degree when applied to oxides of one type, it does not hold in comparing oxides of different types.

TESTS OF OXIDES

Since the absorption of hydrogen sulphide is the main thing desired from the oxide, it follows that tests which will indicate the absorbing value of a particular oxide are the most logical ones to apply in valuing a material. Such tests have been devised but no test which has yet been suggested is sufficiently definite in its provisions and indicative of the results to be obtained in actual practice to thoroughly meet the requirements of a standard test. This is evidenced by the fact that the Purification Committee of the American Gas Association is now endeavoring to devise such a standard test, which will meet the requirements of the gas industry generally.

One of the simplest and best-known laboratory tests worked out thus far is that of A. F. Kunberger[1] (see Appendix C). In the Kunberger method a small weighed sample of oxide is fouled by dry hydrogen sulphide for one hour, the water liberated by the reaction being retained in a tube containing granulated fused calcium chloride, which is weighed with the tube containing the oxide before and after fouling. The gain in weight of the two tubes (or one tube containing both oxide and calcium chloride may be used) is equal to the weight of H_2S absorbed.

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[1] Some of the Physical Characteristics of Ferric Oxide: Proc., Amer. Gas Institute, 1913.

Such a test is very useful in determining the relative capacities of various materials under the conditions of the test. The test is also said by some operators to check practical operations quite closely. Other operators, however, place less reliance in it, and in purchasing an oxide of unknown quality are not satisfied with anything less than a semi-commercial test. Such a test usually consists in fouling two oxides, one of known practical performance, the other the unknown material, with unpurified gas, in a pair of small purifiers. These purifiers may contain from a few quarts to a few bushels of the materials in one or more layers. Sometimes two sets of two or more purifiers each are used. The purifiers are followed by gas meters to measure the gas passing through each oxide. The test usually consists in passing gas through both materials at the same rate and noting the volume of gas purified by each until the time when some hydrogen sulphide passes one material as shown by a test with lead acetate paper at the outlet. The rate of gas flow at the beginning of the test is generally at least twice that usual in practice. Sometimes when one material begins to pass hydrogen sulphide the rate of flow is reduced until absorption is complete and the test continued at the new rate until H_2S again passes the material. The test may be continued until both materials are entirely fouled and in some cases the materials after revivification are tested again. Such a test would seem to possess advantages over a strictly laboratory test, since the same kind of gas is used that has to be purified in the works purifiers and the rate of fouling is nearer to that obtaining in practice. On the other hand, in small test installations where the surface of contact between the oxide and the box is usually relatively much greater than in practice, there is danger of the gas passing up the sides of the box to a considerable extent and the excessive rates of purification are likely to cause channelling. Another disadvantage of tests of this kind is the time required to complete them. With rates of fouling approaching those in practice, weeks or even months may be required to foul the materials.

In all tests of oxides, the great difficulty is to interpret the results fairly and with certainty. At present those gas companies who make extensive tests on oxides interpret the tests as best they can in accordance with their own particular conditions and the opinions of their own engineers, and until a standard test with carefully specified equipment and testing procedure is worked out, it will be very difficult properly to evaluate commercial purifying materials.

ACTIVITY AND CAPACITY OF OXIDES

The existing overloaded condition of the purifying apparatus in many gas plants necessitates more attention to the activity or speed of oxides than has hitherto been given to the subject. A satisfactory test must indicate the relative activity of the materials under test. At the same time capacity of oxides will remain an important consideration. The Steere formula allows about 6 minutes time of contact of gas with oxide, assuming all the space occupied by the oxide to be free space. The actual free space in a layer of oxide will of course be considerably less than the total volume, depending upon the coarseness of the material, a factor which is continually changing as the material is used and becomes more and more clogged with sulphur. A new oxide sponge might have 60 to 70 per cent free space, and therefore the actual item of contact would be considerably less than 6 minutes as mentioned above. If, as is sometimes the case, the time of contact in a heavily loaded purifying system is reduced to 2 minutes or less, it is evident that the rapidity of the material may have a very important bearing on its value for such a plant. It is quite likely that various factors could be worked out applying to various types of purifying oxides, which introduced into formulas for purifying capacities would materially alter the hourly capacities permissible with an equipment of a given size and arrangement. This subject needs further study. For the present the differences in oxides will not be considered in studying the purifying conditions in Illinois plants. Computations will be made, assuming that all oxides are the same. In drawing conclusions and suggesting remedies for certain cases, the possibility of using more rapid oxides must be borne in mind.

CONDITIONS FOUND IN ILLINOIS PLANTS

Having considered the conditions affecting purifying efficiencies, let us see what the actual conditions are in Illinois plants, so far as can be determined from the information collected.

As was mentioned earlier in this bulletin, sixteen of the medium-size plants of the State were visited. Information was gathered relative to load conditions, size and kind of equipment, operating methods, and to a certain extent, the results obtained. This latter information was supplemented by the results of analyses of spent oxide samples collected in the various plants.

Upon returning to headquarters the information obtained was tabulated, purifier capacities were computed, oxide samples were analyzed, and the results tabulated. Half of the plants visited were mixed-gas plants. Their problems were somewhat different from those of straight water-gas plants, so the data and results have been tabulated separately. In accordance with an oral agreement under which results were obtained, the tabulations contain no plant names. The writers will be glad to inform any operator as to the designation of his own plant, in order that explanations may be made in case of misunderstanding or difference of opinion as to results obtained.

EQUIPMENT CONDITIONS

The purifying equipment conditions in Illinois plants are probably the same as those existing in similar plants elsewhere. There is the usual combination of old and new equipment which results from piecemeal construction. The old equipment has often been outgrown, but in many cases is still serviceable, and the usual policy has been to increase capacity by adding another purifier, usually of the outdoor type, to the older indoor equipment, retaining the latter in service. Such a condition exists in about half of the plants inspected.

While it is of course advantageous to get as much economical service as possible from a given unit of equipment, it appears in some cases that the old equipment is a drag on the new. In making additions in some cases, the minimum cost of the addition has been looked after, rather than operating economy. The connections are so arranged as to permit both the old and new equipment to be used at the same time, but with little regard to the flexibility of the system. The arrangement is often so fixed as to permit only one order of the boxes in series. In some cases there is a certain latitude for arrangement among the old units, but usually the new equipment either precedes or follows the old in a fixed position relative to it. Most of the new purifiers are equipped for deep layers of oxide and valved for reversible flow, whereas most of the old boxes have shallow oxide layers and straight flow. In no case which we recall is there a combination of old and new equipment in use, provided with arrangements for perfect flexibility as to rotation of boxes and reversibility of flow. In about half the plants are the boxes uniform as to size and type and completely flexible as to arrangement.

The computation of purifier capacity for many of the plants is a rather complicated matter. The Steere formula is applicable primarily to boxes arranged for reversible flow, though the formula can be applied to straight-flow boxes by the use of an appropriate factor. In some plants where there is a combination of reversible and straight-flow boxes, it is necessary to use one's judgment in the selection of the proper factor, and opinions of two engineers might differ as to the proper value of the factor to be taken.

PURIFYING EQUIPMENT OF INDIVIDUAL PLANTS

The following is a brief description of the purifying equipment of the various plants inspected, together with remarks relative to special conditions which seem noteworthy and pertinent.

Plant No. 1. The purifying equipment of this straight water-gas plant consists of three cylindrical steel outdoor boxes, each 35 feet in diameter and 13 feet high. Each box contains two layers of oxide 4 feet deep. The arrangement is entirely flexible, permitting the boxes to be used in any desired order. The direction of gas flow in each box is reversible, the gas entering between the layers and leaving at the top and bottom or vice versa. Southern Illinois coal is used as generator fuel in this plant and the gas at the purifier inlet contained 180 grains of H_2S per 100 cubic feet at time of inspection. The computed hourly capacity of the purifiers is 240,000 cubic feet, or nearly 2.2 times the maximum hourly make reported. The installation is therefore oversize and with good oxide would permit the use of coal of considerably higher sulphide content, if other conditions made it desirable. The cost of purification per thousand cubic feet in this plant should be very low, unless the capital charges on an equipment so considerably oversize are excessive. No figures relative to capital charges are available. Analyses of spent oxide from this plant indicate that best results are not being realized from this equipment, the sulphur absorption per bushel not being nearly so high as in several other water-gas plants that are much more heavily loaded.

Plant No. 2. The purifying equipment in this plant consists of two cylindrical dry-seal straight-flow indoor boxes, 18 feet in diameter and 9 feet deep. Each box contains two 4-foot 3-inch layers of oxide. The generator fuel used at time of inspection was eastern coke and the H_2S content of the unpurified gas was 100 grains per 100 cubic feet. The computed hourly capacity of the boxes was 39,800 cubic feet of gas, which could theoretically be increased to about 52,000 cubic feet per hour by arranging for reversible flow. while the maximum hourly make was reported as 110,000 cubic feet. The sulphur absorption per bushel in this plant was low, as would be expected in a plant so overloaded. The situation was complicated by insufficient condensing apparatus and by a relief holder having but one connection, giving but slight opportunity for any cooling of gas in the holder. At the time of inspection the gas was entering the boxes at a temperature of about 120°F. and was carrying much tar fog. Analyses of spent oxide, however, indicate that this is not a year-around condition. The purifying condition in this plant were the most unfavorable observed in the State, and it is greatly to the credit of the operators that they succeeded so well in supplying clean gas to the public. The shortcomings of the present cleaning and purifying systems are realized by the management, and extensive improvements are projected.

Plant No. 3. The equipment of this water-gas plant consists of three dry-seal, oblong, indoor boxes 16 feet by 12 feet horizontal section, and 12 feet deep. Each box contains two 5-foot layers of oxide. These boxes were originally designed for reversible flow. The superintendent conceived the idea that the capacity would be increased by making straight-flow boxes of them. The computed capacity was thereby reduced from 55,200 to 40,800 cubic feet per hour with gas containing 190 grains per 100 cubic feet. Whether decrease in efficiency has resulted from the change would be extremely difficult to determine, since recent improvements in the tar-extracting apparatus have probably increased efficiencies to a far greater degree than the change referred to decreased them. Since the purifiers are now overloaded nearly 100 per cent, a return to the former arrangement which would involve very little expense, is suggested.

Plant No. 4. This is an up-to-date small water-gas plant. The purifying equipment consists of two cylindrical reversible flow outdoor boxes 14 feet in diameter and 10 feet high, each containing two layers of oxide 4½ feet deep. The computed maximum hourly capacity is 25,000 cubic feet of gas, containing 175 grains H_2S per 100 cubic feet, and the reported maximum hourly make is 22,000. Since no air is admitted for revivification the reversibility of these boxes is a matter of less consequence than would otherwise be the case and the actual capacity is probably less than the computed. The plant is seldom operated more than 12 hours per day. In addition to these working boxes there are four square indoor water-seal, straight-flow boxes, 10 feet in diameter and 4 feet deep, designed to hold one 3-foot 6-inch layer of oxide each. These boxes are relics from a former coal-gas plant. They are connected by a center seal, so that only three of them can be in service at one time. The feasibility of putting these boxes into service so as to permit the use of generator fuel (bituminous) of higher sulphur content has been considered. Inasmuch as the coal suggested for use gives about 400 grains of H_2S in the gas, and the two boxes now in use would have a computed maximum hourly capacity of 22,000 cubic feet of gas of that sulphur content, it hardly seems that the slightly increased hourly capacity to be obtained from the small old-type boxes would warrant the expense of putting them into service and the inconveniences attending their use.

Plant No. 5. The purifying equipment of this plant was originally designed for coal gas. Extensive necessary repairs to the coal-gas equipment, difficulty of securing efficient retort-house labor, and the economies realized from making water gas from bituminous coal have resulted in at least temporary abandonment of the coal-gas equipment except in so far as it could be utilized in handling the water gas. The purifiers include two existing dry-seal indoor boxes 15 by 10 by 8 feet deep, each containing two layers of oxide 3½ feet deep, and one square dry-seal box 20 by 20 by 5 feet deep, containing one layer of oxide 4½ feet deep. The boxes are all of the straight-flow type. The large shallow box can be used only as a catch box, being necessarily last in the series. The computed capacity of the purifiers is 32,700 cubic feet of gas per hour, and the overload during hour of maximum make is about 22 per cent. The present arrangement of the boxes fulfills present needs quite well. By arranging the two deep boxes for divided and reversible flow, the capacity could be increased to about 36,500 cubic feet per hour. The purifying costs reported are quite low.

Plant No. 6. The purifying equipment of this water-gas plant consists of two rectangular indoor boxes 16 by 12 by 11½ feet, each containing two 5-foot layers of oxide, in parallel with two boxes 20 by 20 by 5 feet containing one 4-foot layer of oxide each. The deeper boxes are arranged for reversible flow, but the shallow boxes have straight flow only. The computed capacity of the system as now arranged is about 60,000 cubic feet per hour. The overload at the time of maximum make is about 67 per cent. It is understood that a rearrangement of the boxes whereby all the boxes would be in series, has been considered. If such a change were practicable from other considerations, the capacity would be increased slightly but probably not sufficiently to pay. On the other hand, if plenty of overhead room is available, and it were practicable to double the depth of the two shallow boxes, making two layers in each box, and to arrange the whole system for reversible flow throughout, the capacity would be increased to over 100,000 per hour or to about the present maximum hourly production of the plant.

Plant No. 7. This large suburban water-gas plant is equipped with four rectangular water-sealed indoor boxes each containing two 5-foot layers of oxide. The gas flow in each box is reversible, gas entering at the middle and leaving at the top and the bottom of the box or vice versa. Rotation of the boxes can be accomplished in only one direction, as: 1 — 2 — 3 — 4, 2 — 3 — 4 —1, etc., but not 4 — 3 — 2— 1, etc. The computed hourly capacity of the system is about 206,000 cubic feet. It is about 40 per cent overloaded at time of maximum production. The purifying costs in this plant are the lowest reported by any plant inspected. The spent oxide from this plant showed a sulphur content rather above the average. The tar content was higher than the average found in all the plants and indicated that an excessive amount of tar had been allowed to enter the boxes at some time during the life of the oxide. At the time of inspection, the gas entering the boxes was reasonably clean. The indications are that purifying results could be improved somewhat if the load curve, shown in Figure 2, could be smoothed out, making the production through the boxes more uniform.

Plant No. 8. This suburban water-gas plant has two sets of purifying boxes in parallel. One set consists of four rectangular indoor boxes connected by a center seal which permits the use of only three boxes at a time. Each box is 24 by 24 by 7 feet deep and contains two layers of oxide 3 feet deep. The other set of boxes consists of four boxes, each 16 by 16 by 4½ feet deep. Each box contains a single layer of oxide 2½ feet deep. Three of the boxes are interchangeable, viz., any one of them can be made first box, but the position of one box fixes the order of the set. The fourth box of the set is a catch box and is always at the end of the series. All the boxes in both sets are arranged for straight upward flow. The computed maximum capacity of the two sets of boxes, as now arranged, is about 100,000 cubic feet of gas per hour. The capacities of the two sets are so different (about 4 to 1) that any rearrangement by placing in series would probably not be feasible. The set of larger boxes has a present capacity of about 80,000 cubic feet of gas per hour. If a new valving system could be installed, putting the fourth box into use and permitting reversal of flow, the capacity of the set would be approximately doubled, giving the entire system a total capacity of 180,000 cubic feet, more or less, per hour, which is about equal to the present maximum flow through the purifiers.

Plant No. 9. This plant produces about 60 per cent water-gas and 40 per cent coal-gas. Each kind of gas has an independent condensing system and the gases are mixed at the inlet of the purifiers. The purifying equipment consists of six boxes. Of these, four indoor boxes are arranged in two pairs, the members of each pair being connected in parallel and each pair acting as one divided-flow but non-reversible box. The paired boxes are 16 feet square in horizontal section and contain one layer of oxide each, three feet deep. The remaining boxes include an outdoor cylindrical steel box 25 feet in diameter and 10 feet high, containing two 4-foot layers of oxide, and an indoor catch box 16 by 16 by 4 feet deep, containing one 4-foot layer of oxide. The paired units and the cylindrical box can be arranged in various orders as 1 — 2 — 3, 3 — 1 — 2, and 2 — 3 — 1. The direction of flow except in the cylindrical box is non-reversible. The history of the development of this installation is not known. It seems likely that the original installation consisted of a four-box set arranged with a center seal as is common in old installations. In adding to the original equipment, an arrangement was made which is more flexible than is found in many plants. The computed hourly capacity is about 70,000 cubic feet per hour, which is ample for present needs.

Plant No. 10. This mixed-gas plant puts out about 90 per cent coal gas on the average. The peak load on the purifiers is rather sharp, the maximum hourly production being about 9.5 per cent of the maximum daily production. The purifiers include two cylindrical outdoor boxes 15 feet in diameter and 12 feet high arranged for reversible flow. Each box contains two 5-foot layers of oxide. The computed maximum capacity is about 30,000 cubic feet per hour and since the maximum hourly production through the boxes is said to be 75,000 cubic feet, there is a large load factor. The storage capacity in this plant is about 65 per cent of the maximum day. Water-gas and coal-gas are cleaned separately and mixed at the inlet of the boxes. The coal-gas production will probably average around 540,000 cubic feet per day, with an hourly production of about 20,000 cubic feet. The maximum daily gas output from the plant is reported to be about 800,000 cubic feet, which indicates that the maximum water-gas production may be about 32.5 per cent. The overload on the purifiers then is evidently due to the pumping of water-gas through the purifiers at an exceptionally high rate during peak load. It would seem, however, that if the maximum hourly output of the plant for a peak lasting say four hours at a time averaged no greater than the reported maximum make through the boxes, namely, 75,000 cubic feet per hour, and if the holders were full at the beginning of the peak, there would be no necessity of pumping gas through the purifiers so fast, even were it ncessary to retain the city holder two-thirds full at all times. Even were the load curve smoothed out as much as possible, with the existing storage capacity it is likely that there would be a considerable overload during maximum hours. The logical extension of the purifying system would seem to be the installation of another box similar to those now in place. Another such box would bring the hourly capacity up to about 50,000 cubic feet per hour.

Plant No. 11. This small mixed-gas plant has an average output of about 200,000 cubic feet of gas per day, of which about one-fourth is water-gas. The maximum hourly purification is about 12,000 cubic feet. The purifying equipment consists of two cylindrical outdoor purifiers, 15 feet in diameter and 12 feet high, containing two 5-foot layers of oxide each. The flow is divided and reversible. The computed capacity of these purifiers is about 30,000 cubic feet per hour; therefore the system is much underloaded. It would be interesting to know the capital charges on an oversize system of this kind, but no figures are available. The size of the purifiers is ample to care for the growth in output for some years to come.

Plant No. 12. The purifying equipment of this plant which produces only 10 to 15 per cent water-gas, consists of four water-sealed indoor boxes 16 by 16 by 7.5 feet deep, each containing two layers of oxide 2.75 feet deep. Three of the boxes are arranged for rotation, the possible arrangements being 1 — 2 — 3, 2 — 3 — 1, 3 — 1 — 2, but not the reverse. The fourth box acts as a catch box and is always in last position. The computed capacity of this installation is about 44,800 cubic feet. If the boxes were valved for divided reversible flow, and 2 per cent of air used for revivification in place, the computed capacity would become about 61,000 cubic feet per hour. At present the installation is about 25 per cent overloaded at time of maximum hourly production, but since the load is being handled well and the cost of purification is low, there is little reason for making a change. The use of higher sulphur coals, if desirable or necessary for other reasons, might make the suggested change advisable.

Plant No. 13. The original purifying equipment of this plant, which makes about 40 per cent water-gas, consisted of two rectangular, water-sealed, indoor boxes, each 16 by 24 by 5 feet deep and containing one layer of oxide, 4 feet 4 inches thick. A cylindrical outdoor box, 15 feet in diameter and 12 feet high, containing two 5-foot layers of oxide was subsequently installed. The new box is of the divided-flow reversible type. On account of tar trouble, the first rectangular purifier was emptied and refilled with shavings to act as a shavings scrubber. The remaining rectangular box and the new outdoor box have a combined capacity of about 26,000 cubic feet of gas per hour. As is common in piece-meal installations of this kind, there is little opportunity for rotation of boxes; indeed in this plant there is only one arrangement possible. The rectangular box is always first in series, and the only change possible is reversal of flow in the second box. The overload during maximum hour is only about 15 per cent and there seems little reason for making a change on that account. Greater flexibility with respect to rotation of boxes would be desirable and would probably permit a more nearly complete fouling of the oxide and a reduction in purification labor. If a regular shavings scrubber were installed and the box now used for tar extraction were put into service again as a purifier, the capacity of the installation would be increased to about 35,000 cubic feet of gas per hour.

Plant No. 14. This plant makes about 95 per cent coal-gas and the purifying results obtained are considerably above the average. Seven boxes are in use, of which three boxes handle coal-gas exclusively, while the remaining four handle a smaller part of the coal-gas and all the water-gas. The purifiers are arranged in two parallel groups. One group consists of two 24 by 24 by 5 foot boxes, each box containing one layer of oxide 4 feet 6 inches in depth, and one 24 by 24 by 12 feet box containing two oxide layers, each 4 feet 6 inches in depth. These boxes are straight flow, but the sequence can be changed. The other group of boxes consists of four rectangular boxes, each 20 feet in diameter and containing one 2 foot 6 inch layer of oxide. These boxes are connected by a center seal and one box is always off. The computed hourly capacity of the first group is about 72,000 cubic feet of gas per hour, and that of the second group about 23,000 cubic feet per hour. Since the maximum hourly production is reported to be 70,000 cubic feet, the system is not overloaded, at least with gas of the present sulphur content. In case an increased capacity were necessary, it might be desirable to build up the two shallow 24-foot boxes to conform with the existing deep box of the same area. Such an enlargement with valves so arranged as to give complete reversibility would increase the hourly capacity of this group from 72,000 cubic feet to 157,000 cubic feet per hour, over 150 per cent of the present total capacity. Similarly, the four shallow boxes of the other group, if built up to double depth and arranged for complete reversibility, would have a capacity of about 100,000 cubic feet per hour.

Plant No. 15. This small mixed-gas plant produces about 40 per cent water-gas. The purifying equipment consists of four old-type, indoor, water-sealed boxes, connected by a center seal which permits the use of only three boxes at one time. The boxes are 10 by 8 by 4 feet and each contains one 3-foot 6-inch layer of oxide. The calculated capacity of the installation as now arranged is only about 6,000 cubic feet per hour, while the maximum load is reported to be 15,000 cubic feet, and the average load 7,000 cubic feet per hour. It is evident, therefore, that the installation is heavily overloaded. If the fourth box could be put into service except for the short interval required to change a box, the capacity would be increased to about 7,500 cubic feet per hour, which would still leave 100 per cent overload. A new purifying system, or the addition of one up-to-date box with proper valving, would perhaps be the best solution. The present single boxes, if built up to double height and arranged for complete reversibility of flow, would have a computed hourly capacity of about 22,600 cubic feet. Such conditions as head room available, strength of supports of the present system, condition of present boxes, and cost of the improvements would of course determine the best way to increase capacity. The fact that the purifying labor cost per 1,000 cubic feet in this plant is about double that of any other plant inspected (other small plants included) indicates that there is sufficient economy to be realized in labor charges to offset a considerable capital charge.

Plant No. 16. This plant makes about 93 per cent coal-gas. The purifying equipment is rather unique among the installations inspected. The system includes two outdoor concrete boxes, each 40 by 26 by 14 feet 4½ inches deep, each containing one 53-inch layer and one 62-inch layer, two indoor boxes each 30 by 20 by 5 feet deep, containing one 4½-foot layer, and two indoor boxes 20 by 20 by 4½ feet deep containing one 3-foot 9-inch layer each. The greater part of the purification is done in the two concrete boxes. These are placed first in the series and the order cannot be changed, nor is there any rotation of the two boxes though they are valved for divided reversible flow. Coal-gas only is purified in the concrete boxes. The old type indoor boxes follow the concrete boxes and the water-gas enters the inlet of the former. The old purifiers are all single-layer straight-flow boxes and are all arranged in series. The computed capacity of the whole system is about 190,000 cubic feet of gas per hour while the maximum hourly purification is reported to be only 40,000 cubic feet. It is evident, therefore, that the capacity is ample for some time to come. This plant was the only one inspected in which the oxide was revivified in the box by an air blast. Only the oxide in the large concrete boxes could be revivified in this manner. The way in which revivification is conducted in this plant will be discussed later.

SUMMARY OF CAPACITIES AND LOAD CONDITIONS

Tables 1 and 2 give the summarized data relative to load conditions, storage capacity, purifier capacity, etc., of the plants visited.

TABLE 1.—Purifier load conditions in medium-size water-gas plants of Illinois.

Plant.	Aver. daily output—M cu. ft.	Maximum daily output—M cu. ft.	Aver. hourly make thru purifiers—M cu. ft.	Max. hourly make thru purifiers—M cu. ft.	Holder capacity—M cu. ft.[1]	Holder capacity—per cent. max. day	H_2S in gas—grs. per 100 cu. ft.	Bushels oxide in actual use	Bushels oxide per million cu. ft., max. day	Calculated max. hourly capacity of purifiers—M cu. ft.	Max. hourly make—per cent of max. purifier capacity	Aver. hourly make—per cent of maximum purifier capacity
1	1650	1800	69	110	C - 1800 R - 60	103	180	18463	10250	241	45.6	28.6
2	1400	2000	58	110	C - 500 R - 112	30	100	4420	2210	40	277.0	145.5
3	617	712	26	80	C - 300 R - 75	53	190	4625	6500	41	196.0	63.7
4	170	227	7	22	C - 100 R - 50	66	175	2225	9810	25	88.0	28.0
5	360	430	15	40	C - 290 R - 30	72	130	3127	7280	34	119.2	44.8
6	1450	1600	60	100	C - 973 R - 80	66	125	6285	3920	54	186.0	111.6
7	3880	6000	161	280	C - 5000 R - 100	85	100	17125	2865	206	136.0	78.1
8	3200	4100	133	175	C - 500 R - 100	15	125	10900	2660	104	168.8	79.0
Averages............................						61	141	....	5686	....	145.8	72.4

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[1] In holder capacity column, the abbreviations "C" and "R" stand for City Holder and Relief Holder, respectively.

TABLE 2.—Purifier load conditions in medium-size mixed-gas plants of Illinois.

Plant	Per cent water-gas	Aver. daily output—M cu. ft.	Max. daily output—M cu. ft.	Aver. hourly make thru purifiers—M cu. ft.	Max. hourly make thru purifiers—M cu. ft.	Holder capacity—M. cu. ft.[1]	Holder capacity—per cent of max. day	H_2S in gas—grs. per 100 cu. ft.	Bushels of oxide in actual use	Bushels of oxide per million cu. ft., max. day	Calculated max. hourly capacity of purifiers—M cu. ft	Max. hourly make—per cent of purifying capacity	Aver. hourly make—per cent of purifying capacity
9	60	850	1200	35	60	C - 1280 R - 60	107	90	6450	5360	65	91.8	53.5
10	10	600	800	20	75	C - 300 R - 200	62	230	840	3560	30	45.0	65.8
11	25	200	230	8	12	C - 100 R - 50	65	340	2840	12300	29	39.4	28.4
12	12	550	780	23	50	C - 663 R - 112	99	220	3560	4690	45	111.5	51.1
13	40	440	500	18	30	C - 525 R - 21	109	150	2755	5500	26	114.5	69.8
14	5	1500	1800	63	70	C - 902 R - 70	54	165	10735	5960	96	73.0	65.5
15	40	170	200	7	15	C - 100 R - 75	83	350	675	3370	6	256.0	121.0
16	7	1400	1800	58	65	C - 1000 R - 390	77	470	22805	12700	191	34.0	32.9
Averages							82	252	....	6680	....	120.6	61.0

[1] In holder capacity column, the abbreviations "C" and "R" stand for City Holder and Relief Holder, respectively.

In studying Tables 1 and 2 several outstanding facts will be noted. Of the eight water-gas plants, six are loaded at maximum hour beyond the rated capacities of their purifiers, while on the other hand, only two of the eight are overloaded during hours of average production. It is evident then that the lack of uniformity of load is the chief cause of overload. It will be noted that the maximum hourly make is often more than double the average hourly make. (By "make" here, is meant flow through purifiers, *not machine make.*) By referring to the column marked "Calculated max. hrly. capacity of purifiers" and "Bushels of oxide per million cu. ft., max. day", we are able to form some opinion as to the reason for the overloaded or underloaded condition in each case. It is interesting to note that the average number of bushels of oxide per million cubic feet of gas purified on the maximum day, namely 5,686, agrees quite closely with the figure 5,365, which is the average of twenty-three water-gas plants whose results are reported by O. B. Evans in his paper, "Revivification in place", already mentioned. This indicates that Illinois plant conditions conform quite closely to conditions in plants all over the country, as is to be expected.

While, as shown in the tables, the holder capacity bears no direct relation to purifying capacity, it will be noted that in plants where the volume of oxide is small, large holder capacity assists in keeping down the overload. Plants 1 and 2 are interesting as the extreme examples of prevailing conditions. These plants have approximately the same output. Plant 1, however, has a holder capacity greater than its maximum day and an oxide capacity per million cubic feet of gas nearly twice the average. Plant 2, on the other hand, has a holder capacity only 30.6 per cent of its maximum day and an oxide capacity less than half the average. It is surprising to find that despite these great differences, the amount of sulphur absorbed per bushel by both of these oxides is almost the same with a very slight advantage in favor of Plant 1. The probable reasons for this similarity of results under such different conditions will be discussed later in connection with Table 3. Plant No. 8 (see Table 1) presents an apparently anomalous condition. Here the holder capacity is only 14.6 per cent of the maximum day and there is less than half the average amount of oxide per million cubic feet on maximum day found in all the plants, yet the overload is not nearly so great as in some other plants which are apparently more favored. The reason, however, seems to lie in the connection of this plant with a larger system whose holder capacity is to a certain extent available for use by this plant. In this case it is practically impossible to say just what average holder capacity is available for Plant No. 8, though its own individual holder capacity is as given. Probably at least four times the capacity stated is actually available when needed. Formerly many gas engineers considered that a well-designed plant should have a holder capacity at least equal to its maximum day, but the rapid growth of output in most of our plants has resulted in much smaller storage capacity ratios, as shown in Tables 1 and 2. When one considers that in spite of the smaller margin of safety which a small holder capacity gives, practically all of the larger plants operate year after year and give the public uninterrupted service, one is likely to conclude that there is no well-defined lower limit beyond which the gas operator dare not go. While this is true to a certain extent and distribution conditions are likely to be the determining factor in dictating an increase in storage capacity, it is evident that this condition is reflected back upon plant operation and affects purification, tar removal, and indeed any phase of the gas manufacturing process in which rate of gas flow is a factor.

In Table 2, the purifier load conditions in eight mixed-gas plants are presented. It is to be noted that the percentage of water-gas varies from 5 to 60 per cent of the total, averaging 25 per cent in all plants. It will be observed that the average holder capacity is larger in proportion to the maximum daily output than in the straight water-gas plants, as is also, in general, the volume of oxide per million cubic feet output on maximum day. Only one of the mixed-gas plants had an overload on its purifiers, during hours of average production. Since the coal-gas production in a mixed gas plant is usually fairly uniform in rate, the water-gas production taking the peak load, it is evident that in most cases where the purifiers are overloaded,the overload is caused by the production and purification of a large volume of water-gas in a short time. The purifiers are usually designed to handle the coal-gas production, but the water-gas production has often not been provided for. It will be noted that the hydrogen sulphide content of the gas, while about double that found in the eight water-gas plants, is considerably lower than in usual coal-gas practice, even with very low-sulphur coals. Had the sulphur content been higher, then the average purifying capacity would have shown an overload according to the relation shown in Figure 1.

EFFECT ON PURIFIER CAPACITIES OF THE USE OF ILLINOIS COAL

In connection with the influence of sulphur content of the gas on purifying capacity, it is interesting to note the effect of a change from the low-sulphur fuels used in a majority of the plants at the present time to fuels of higher sulphur content. The water-gas plants listed in Table 1, with the exception of Plants 2 and 8, were using Illinois or Indiana coals as generator fuel at the time of inspection. These two plants were using eastern cokes. The coals were in all cases selected low-sulphur coals. It will be noted that in some of the plants using coal, the H_2S content of the gas is no higher than in those using coke. In general, however, the increase in sulphur content with Illinois or Indiana low-sulphur coals as generator fuel would be from 50 to 100 per cent, viz., an H_2S content in the gas of 150 grains to 200 grains per 100 cubic feet might usually be expected. By reference to Figure 1 it will be noted that an increase of 50 to 100 per cent in the H_2S content of the gas does not have nearly the effect on the rated purifier capacity, when the H_2S content is small, that a similar percentage increase would have if the H_2S content were large. Hence a change from a low-sulphur eastern coke as water-gas generator fuel to a low-sulphur central district coal does not have as great an effect as the change from a low-sulphur eastern gas coal to a low-sulphur Illinois coal would have in coal-gas manufacture, it being assumed, as is usually the case, that the best eastern gas coals will average lower in sulphur content than the best Illinois coals. It is interesting to take numerical examples to study the effect of such changes.

Assume that an eastern coke as generator fuel gives gas containing 100 grains of H_2S per 100 cubic feet, and that a central district coal, using the same oil for enrichment gives gas containing 200 grains per 100 cubic feet. A plant which was designed to purify 100,000 cubic feet of gas of the lower sulphur content per hour would have its capacity reduced to 96,000 cubic feet—a decrease of only 4 per cent. On the other hand, if a low-sulphur eastern gas coal gave 300 grains of H_2S at the inlet to the purifier and an Illinois coal gave, as reported in some cases, 600 grains of H_2S, then a plant equipped to handle 100,000 cubic feet of the lower-sulphur gas per hour would have its capacity reduced by the change to about 83,000 cubic feet,—a decrease of about 17 per cent.

All the mixed-gas plants listed in Table 2 except Plants 13 and 15 were using low-sulphur eastern coals at time of inspection. In Plants 13 and 15, mixtures of 50 per cent eastern and 50 per cent Illinois coal were used. In neither of these plants was the sulphur content of the gas exceptionally high, but of course the 40 per cent water-gas made in both cases tended to reduce the sulphur in the mixed gas. It is evident that a decrease of 17 per cent or more in the purifying capacity of some of the mixed-gas plants given would be a serious matter. This difficulty might be met to a considerable extent by more attention to certain details of operation and selection of oxides, as has been previously discussed.

OBSERVED RELATION OF OXIDE VOLUME TO PURIFIER CAPACITY

In Tables 1 and 2 have been given the number of bushels of oxide in use in each plant per million cubic feet of gas output on maximum day. These figures have not been used in computing purifying capacities but are given partly because some engineers have been accustomed to rate purifiers in this manner, and partly to show the effect of oxide volume on purifying capacity in the various cases; especially in connection with storage capacity and load conditions. In Figure 3 is plotted the relation observed between oxide volume and maximum hourly purifying capacity in the various plants. The dotted line represents 1/10 bushel of oxide per cubic foot of gas purified during maximum hour, and is drawn in for convenience of comparison. The water-gas and mixed-gas plants are plotted separately. It is evident that the sulphur content of the gas determines, to a great extent, the position of the curves, and therefore any specification which calls for a certain number of bushels of oxide per 1,000 cubic feet of gas to be purified in a given time can at best be only incomplete. It is interesting to note that the curves for mixed-gas and water-gas plants, while quite close together for the smaller plants, appear to diverge after the 100,000 cubic feet per hour production is passed. Whether this would hold generally for the larger plants cannot be stated on account of insufficient data.

One rather remarkable thing is shown by Tables 1 and 2, namely, that purifiers may be worked far beyond their capacities and still do the work required of them. There does not seem to be any definite point, at least within the range observed, where the purifiers actually break down suddenly in their performance. It is conceivable that gas could be passed through a series of boxes containing new oxide at such a rate that hydrogen sulphide could be detected almost immediately at the outlet of the system. In testing oxides on a laboratory scale, this condition is found and is made use of to determine the relative rates of reaction of various oxides.

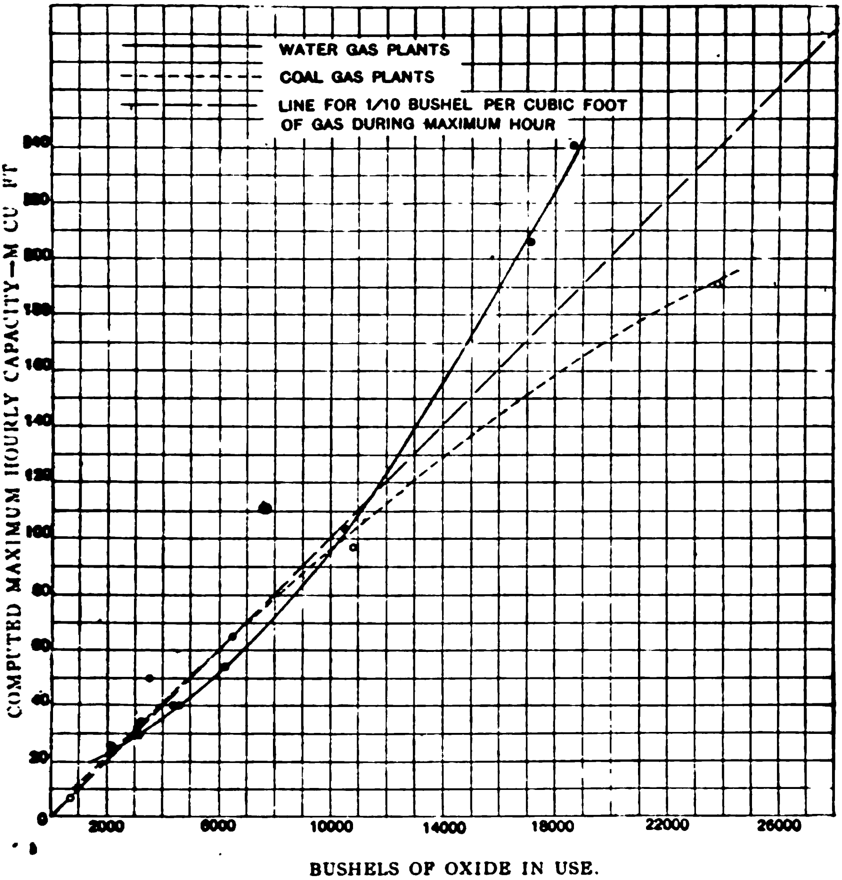

FIGURE 3—Observed relation of oxide volume to hourly purification capacity.

The time of contact called for by the Steere formula is approximately 6 minutes. Many comparatively slow oxides will not give a test for hydrogen sulphide immediately on a gas containing 100 grains per 100 cubic feet unless the time of contact is reduced to approximately 0.5 minutes. Other more rapid oxides will absorb all of the hydrogen sulphide from gas containing 100 grains of H_2S for several hours with this time of contact. As the oxide becomes fouler, however, the rate of absorption slows down and eventually some hydrogen sulphide will pass by the box. This will happen more quickly, other things being equal, in a purifying system that is overloaded. The result is that in an overloaded plant, other conditions being the same, more frequent changes will be necessary to keep the gas clean. When the frequency of changes becomes excessive the operator usually has one of the following choices; namely, to enlarge the purifying equipment, to rearrange existing equipment, to improve operation by increasing the absorption per bushel through more complete revivification in place, in some of the ways already discussed, or to find a more active oxide. Sometimes in the more extreme cases, only the first alternative will prove a feasible, permanent remedy.

REARRANGEMENT OF EQUIPMENT TO INCREASE CAPACITY

As just mentioned, the capacity of a purifying installation may sometimes be materially increased by minor changes whereby the existing equipment can be used in a more advantageous way, or the existing equipment may be enlarged, without changing its position or increasing the ground space occupied. Again, internal changes are possible whereby the purifiers may be made to accommodate a greater volume of oxide. Frequently, where the existing equipment is in good condition, such changes may be made at a fraction of the cost of an entirely new installation. Where additional capacity is needed it would often pay to consider (1) whether the best possible performance is being obtained from the present equipment, and (2) whether some minor changes would not secure sufficient additional capacity to defer the installation of new equipment to another time. Of course, in this as in any other construction, there is always some uncertainty as to the relative cost of installation now or a few years hence. Some of the rearrangements which may be made have been suggested in the detailed descriptions of the purifying installations inspected.

In the first place, it may be well to consider whether the amount of oxide is the maximum that the boxes will accommodate or whether the layers are of the greatest thickness permissible. In several instances it was found that the available space for oxide in the boxes, even allowing for the trays and a reasonable amount of free space, was considerably greater than would correspond to the number of bushels said to have been purchased for the boxes.

Again the amount of free space allowed may be excessive. In some cases the trays could be relocated without unduly diminishing the free space.and with a distinct increase in capacity. Take, for example, a 4-box set of purifiers arranged for reversible flow, each box being 15 feet in diameter and 12 feet high, containing two layers of oxide each 4½ feet in depth. The hourly capacity, according to the Steere formula, would be 61,845 cubic feet, if the gas contained 200 grains of H_2S per 100 cubic feet. Now, assuming that the depth of each layer could be increased by 6 inches, the capacity would become 66,262, an increase of capacity of 14 per cent.

If the space available for oxide is being utilized to the fullest extent, then rearrangement may be in order. As has been suggested in several cases, reversible flow may help considerably. Let us assume an installation of three rectangular boxes, each 25 by 25 by 12 feet, each containing two 5-foot layers of oxide equipped for straight flow only, and with a given sequence as ABC, BCA, CAB. Such an installation purifying gas containing 200 grains of H_2S per 100 cubic feet would have a maximum hourly capacity, according to the Steere formula, of 133,000 cubic feet of gas.

Let us assume that this installation is overloaded and that it is desired to increase its capacity about 35 per cent. This increase may be accomplished in either of two ways, namely, by making the three existing purifiers perfectly flexible as to arrangement and reversibility or by installing a fourth box of the same size as the existing boxes, arranged for straight flow only. Leaving out of consideration for the present the difference in operating cost which would be in favor of the former arrangement, let us consider the probable relative costs of the two arrangements. At present prices, the cost of a new box of the size given, arranged for straight flow only, would probably be somewhere between $12,000 and $16,000. The installation of three 6-inch reversing valves, together with alteration of the manifold whereby the three existing boxes could be made entirely flexible as to arrangement and reversibility, would cost somewhere between $6,500 and $11,000, depending of course upon the amount of work and material that would be required and the amount of material from the old manifold that could be applied to the change. It is evident then that if the existing purifiers were in good condition and conveniently arranged for operation, rearrangement would be decidedly cheaper than the addition of another box of the same type. The economy of operation would also be distinctly in favor of rearrangement. A number of installations have been observed in which such a change with corresponding increase in capacity was apparently feasible.

In a few cases where old 4-box sets with center-seal connections are in use, a change in the connections whereby all the boxes could be used at one time would be advantageous.

A few cases have also been observed where a small increase in capacity could be realized by putting into series boxes now arranged in two parallel groups, but in most of the cases of this kind observed, such a change would hardly give enough increase in capacity to pay unless all the boxes were made reversible and arranged so as to be used in any desired sequence. In most cases where two parallel groups are in use, one of the groups consists of shallow single-layer boxes. Frequently these shallow boxes are of considerable cross-sectional area and where substantial foundations exist and plenty of head room is available, it might be feasible to build up the boxes to double height, installing an additional layer of oxide. Such a rebuilt group of boxes, if arranged for reversible flow and for rotation with the boxes of the deeper group, also equipped for reversible flow, would usually increase the capacity of the system very materially. For example, in Plant No. 6 already described, such a reconstruction, if feasible, would increase the capacity by about 66 per cent.

Of course, in making any alterations of the kinds described several things have to be considered. It would obviously be unwise to go to considerable expense to alter the connections of or reconstruct boxes which through long service had become unsound. And it might be unwise to prolong the use of boxes so arranged that the cost of operation was excessively high on account of inconvenient location or poor facilities for handling oxide. In any case it would be advisable to carefully compare the cost of rearrangement or reconstruction with the cost of new equipment necessary to give an increased capacity equivalent to that expected from the proposed change. The possibility that the space now occupied by purifiers especially when in substantial buildings, might be used to advantage eventually for some other purpose should also be considered. Since present practice is almost unanimously in favor of outdoor purifiers, it might be obviously unwise to perpetuate the use of valuable buildings for this purpose. The economic as well as the physical features of such a change need consideration. In all cases where possible changes have been suggested in this paper, it is to be understood that only the results to be expected from such changes have been considered. The considerations just named and physical conditions existing in the various plants might make the suggested alteration entirely impracticable. Each case would have to be considered carefully by itself.

RESULTS OBTAINED IN PLANTS INSPECTED

As will be seen clearly in Tables 3 and 4, purifier capacity alone will not necessarily insure good purifying results. Some of the best results found in Illinois plants at the present time are in overloaded plants.

A study of Tables 3 and 4 shows how difficult or impossible it is to harmonize the results actually obtained with the conditions under which they were obtained. In general, one cannot but be impressed by the difference between the results shown and those generally considered as typical of the best practice. Text books and treatises on gas manufacture usually state that spent oxide will contain from 50 to 60 per cent of sulphur, thereby implying that this degree of sulphiding is usually attained before the oxide is discarded. Yet the results shown in the tables indicate that in the average Illinois plant, at least, not nearly the usually accepted standard of performance is actually realized. In the water-gas plants, excluding Plant No. 5, which was a mixed-gas plant when the materal was fouled. the average percentage of sulphur in the spent oxide was only 21.7 per cent. In the mixed-gas plants, on the other hand, including Plant No. 5, the average was 37.4 per cent. These results are somewhat lower than those reported by Mr. Evans in the paper already referred to. The average absorption in the water-gas plants studied by him was 35 per cent sulphur and in the coal-gas plants 44 per cent. The latter figure is, we understand, for straight coal-gas, whereas the results reported by us in Table 4 are for mixed-gas plants. It is probable, too, that the plants whose results are reported by Mr. Evans are considerably larger in size than the plants in Illinois inspected by us, and therefore the conditions were probably more favorable for good results. Even so, it is apparent that the results generally obtained fall considerably below those considered as good standard practice.

In comparing Tables 3 and 4 one is impressed with the very considerable difference in sulphur absorption in the two gas-making processes. A number of reasons for the difference may be suggested. Coal-gas usually contains considerably more sulphur per unit volume than does water-gas, and according to the law of mass action, the greater concentration of the H_2S in coal-gas increases the rate of absorption. The coal-gas production is also more uniform and the peak loads on the purifiers usually represent a greater rate of water-gas purification rather than of coal-gas, so the average load conditions with coal-gas are more favorable. The ammonia in coal-gas, of which traces pass through the purifiers, may also assist materially in the purifying process by keeping the oxide alkaline. A section of the Purification Committee of the American Gas Association is now studying the effect of this factor.

TABLE 3.—*Purifying Results Obtained In Water-Gas Plants Inspected.*

Plant	Average daily production—M cu. ft.	Max. make hr.—per cent of max. purifier capacity	Bushels oxide per M cu. ft. max. hourly production	Kind of oxide in use	Weight spent oxide—lbs. per bushel	Sulphur in spent oxide—per cent dry basis	Tar in spent oxide—per cent dry basis	Sulphur—lbs. per bu. dry spent oxide	Tar—lbs. per bu. dry spent oxide	Grs. H_2S per 100 cu. ft. unpurified gas	Total gas purified per bu.—M cu. ft.[3]	Method of revivification	Purification labor costs—per M cu. ft.	Purification materials cost—per M cu. ft.	Total purification cost Pc. per M cu. ft.
1	1650	45.6	168	Rusted borings..	34.6	18.2	8.2	6.3	2.8	180	26.0	1% air in gas and outside of box.	...	...	....
2	1400	277.0	40	Rusted borings..	44.1	12.0	3.4	5.3	2.4	100	88.5	Outside box only	.50	.20	.70
3	617	196.0	58	Natural........	26.9	26.7	19.0[1]	7.2	5.1	190	26.6	1½% air in gas and outside of box..	.77	.50	1.27
4	170	88.0	100	Rusted borings..	35.2	15.1	4.6	5.3	1.6	175	22.5	Outside of box only	.30	.80	1.10
5	360	119.2	78	Rusted borings..	65.3	40.1[2]	2.0	26.2	1.3	130	.....	2% air in gas and outside of box...	.10	.98	1.08
6	1450	186.0	63	Rusted borings..	33.3	33.0	1.8	11.0	0.6	125	65.5	1% air in gas and outside of box..	.20	.50	.70
7	3880	136.0	61	Natural	50.5	21.2	8.7	10.7	4.4	100	106.0	1% air in gas and outside of box...	.10	.40	.50
8	3200	168.8	62	Natural.......	38.4	25.8	2.3	9.9	0.9	125	58.9	1½ 2% air in gas and outside of box...........	.60	.50	1.10
Averages...		145.8	79	....	41.0	21.7	6.9	7.9	2.5	140	49.3	....	.37	.55	.92

[1] Indications are that this oxide was tarred badly after it had absorbed most of its sulphur content.

[2] This plant was making straight water-gas when inspected but the spent oxide had been fouled chiefly by coal gas. Results averaged in Table 4.

[3] The figures in this column are based upon the assumption that the H_2S content averaged the same throughout the life of the oxide as at time of inspection.

TABLE 4.—*Purifying Results Obtained In Mixed-Gas Plants Inspected.*

Plant	Average daily production—M cu. ft.	Make max. hr.—per cent of max. purifier capacity	Bushels oxide per M cu. ft. max. hourly production	Kind of oxide in use	Weight spent oxide—lbs. per bu.	Sulphur in spent oxide—per cent dry basis	Tar in spent oxide—per cent dry basis	Sulphur, lbs. per bu. dry spent oxide	Tar—lbs. per bu. dry spent oxide	Grs. H_2S per 100 cu. ft. unpurified gas	Total gas purified per bu.—M. cu. ft.[1]	Method of revivification	Purification labor cost—cents per M. cu. ft.	Purification materials cost—cents per M. cu. ft.	Total purifying cost—cents per M. cu. ft.
5	360	119.2	78	Rusted borings..	65.3	40.1	2.0	26.2	1.3	130	....	....	.100	.980	1.080
9	850	91.8	107	"Home-made" rusted borings	62.8	44.1	5.3	27.7	3.3	90	228	Outside of box only	.608	.600	1.210
10	600	245.0	38	Rusted borings..	65.4	37.2	2.1	24.3	1.4	230	78	Outside of box only	.357	.396	.750
11	200	39.4	246	Rusted borings..	70.3	40.7	3.2	28.7	2.2	340	63	Outside of box only	.386	1.255	1.640
12	550	111.5	71	"Home-made" rusted borings	71.0	32.5	6.0	23.1	4.3	220	78	Outside of box only	.540	....	.540
13	440	114.5	92	Rusted borings..	58.9	30.2	1.7	17.8	1.0	150	88	Outside of box only	....	....	....
14	1500	73.0	153	"Home-made" rusted borings	67.2	44.4	4.8	29.8	3.2	165	134	Outside of box only	.840	.200	1.040
15	170	256.0	45	Rusted borings..	50.0	21.4	4.4	10.7	2.2	350	23	Outside of box only	1.407	.840	2.250
16	1400	34.0	351	"Home-made" rusted borings	75.0	36.4	2.6	27.3	2.0	480	42	In off box with air	.342	.576	.920
Averages		120.6	138		65.1	37.4	3.6	24.0	2.3	239	91		.572	.692	1.180

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[1] The figures in this column are based upon the assumption that the H_2S content of the unpurified gas throughout the life of the oxide was same as at time of inspection.

In the columns of Tables 3 and 4 marked "Total gas purified per bushel—M cu. ft.", the assumption has been made that the H_2S content of the gas was constant and the same as at the time of inspection. The figures reported are probably quite as accurate as the results reported in the purification records of most plants, but owing to the uncertainty of the assumption on which they are based, no claims to great accuracy are made for them.

CAUSES OF LOW EFFICIENCIES

OVERLOAD

The cause of the discrepancy between standard purification practice and the actual results observed in Illinois plants is a complex one. It is probably due to some extent to overload. That an overloaded condition of the purifying equipment can result in low-sulphur absorption is evident from a consideration of the effect of overload on operation. Where the gas has to be passed through the boxes at an excessive rate, although the oxide may at first completely purify it, the condition where it cannot completely remove the sulphur is reached sooner than would be the case if the rate of gas flow were slower. The time between box changes will therefore be shorter with the faster rates.

The complete absorption of hydrogen sulphide requires a measurable time of contact between gas and oxide. When the material is fresh a shorter time of contact seems adequate, but as the surface of the oxide becomes sulphided, a longer time of contact seems to be necessary for complete absorption of hydrogen sulphide by the inner particles of oxide. With very rapid rates of gas flow, the absorption seems to be at first largely superficial, and after the superficial capacity of the material has been utilized, longer contact seems necessary for complete absorption of H_2S.

The absorption of sulphur per change will therefore be less with an overloaded purifying system, and to get the same absorption an oxide will have to be handled more times than would be necessary were the flow slower. Each time an oxide is handled it becomes finer from breakage, and with frequent handling the oxide soon becomes so fine as to favor packing and back pressure. Conditions which lead to overload of the purifiers also usually favor overload of the other gas-cleaning equipment, so that more tar is likely to be carried into the boxes, other conditions being the same, when the purifiers are worked beyond their capacities. Therefore, more rapid tarring and excessive breakage of oxide in an overloaded plant are likely to result in depreciation and discard of the purifying material sooner than in a plant operated at normal capacity.

We note, however, that some of the overloaded plants excel other similar underloaded plants in absorption realized, so this does not appear to be the only or perhaps the most serious cause.

TAR IN THE GAS

Tar in the gas is also a contributory cause, but it is difficult to say in a particular case to just what extent efficiency was reduced by it, for some of the spent oxides collected that are high in tar are also high in sulphur. This would lead one to think offhand either that tar has little effect on sulphur absorption or that most of the sulphur absorption had taken place before the oxide was tarred. In order to determine roughly the effect of tar in the oxide upon efficiency of its absorption of hydrogen sulphide, an experiment was carried out, the results of which are shown in Figure 4.

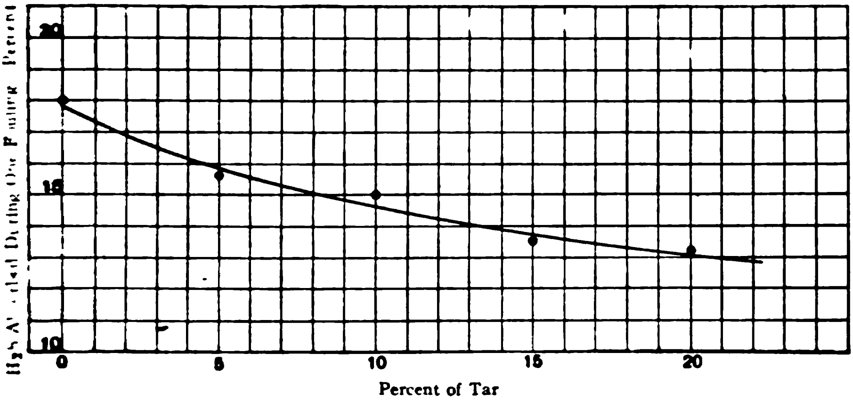

FIGURE 4. Effect of tar on the absorption capacity of an oxide for hydrogen sulphide, first fouling.

The absorption capacity of a particular oxide for pure hydrogen sulphide was determined by the Kunberger method. Portions of the same oxide were then treated with various percentages of tar, and their absorption capacities after treatment were similarly determined. The tar was applied by making up a solution of water-gas tar in pure carbon bisulphide. Each sample of oxide was treated with an amount of this tar solution corresponding to the required percentage of tar. The tar solution and oxide were thoroughly mixed; then the carbon bisulphide was removed by evaporation in the air. The tar was left deposited on the oxide, which was then subjected to the fouling test.

While the conditions of the test and the results obtained are not strictly comparable with practical conditions, they indicate something con-

TABLE 5.—Distribution of tar through beds of oxide in two plants.

PLANT A—WATER-GAS[1].				PLANT B—COAL-GAS[2].			
Level where sampled	Per cent moisture and light oil	Per cent sulphur—dry basis	Per cent tar—dry basis	Level where sampled	Per cent moisture and oils	Per cent sulphur—dry basis	Per cent tar—dry basis
Top of upper layer	39.8	16.86	3.28	Surface of layer	16.2	23.86	2.20
Bottom of upper layer	28.0	23.28	3.46	1 foot below surface	25.3	28.21	.96
Top of lower layer	32.8	24.01	1.60	2 feet below surface	22.4	29.78	1.50
Bottom of lower layer	38.6	17.69	1.59	Bottom of layer	28.6	28.77	1.70

[1] Load on purifiers 169% of rated capacity at time of maximum make. Box contained 2 layers of oxide, each 3 ft. deep.

[2] Load on purifiers 73% of rated capacity at time of maximum make. Box contained only 1 layer of oxide, 2 ft. 6 in. deep.

cerning the effect of tar in coating oxide and decreasing its absorption capacity. Of course, the ability of the material to revivify is also affected, so that tar is a disadvantageous thing to have present at any and all times.

It was thought at first that the reason for the comparatively high sulphur percentages in some rather tarry oxides might be due to the tar-extracting action of a portion of the oxide batch, permitting the remainder of the batch to foul more completely on tar-free gas. It was expected that analyses of oxide from different levels in an upward-flow box would show a concentration of tar in the lower part of the box. Samples of oxide were therefore taken in two plants, one water-gas and the other coal-gas, at various levels. Each sample was collected from several points at the same level, to insure a representative sampling. Analyses of the samples and the levels where taken are shown in Table 5. It is surprising to note that the tar is not concentrated at the bottom. In the water-gas plant the greatest percentage of tar was found in the bottom of the upper layers, while in the coal-gas box, the top of the batch contained the most tar. Likewise, there is no apparent relation between the percentages of tar and sulphur in these batches. The highest percentage of sulphur in each case is coincident neither with the lowest, nor with the highest percentage of tar. One naturally concludes that each batch must have absorbed the larger part of its sulphur in each case before the tar was present to any great extent. The concentration of tar in the upper part of the batch may be caused by tar condensing out of the gas, due to the cooling action of the purifier box cover, and dropping down into the oxide. Of course, in practice the accumulation of tar is relatively slow, and since the rate of sulphur absorption in a given part of an oxide batch is slowing down as the concentration of iron sulphide increases, it is difficult to determine in a particular case to just what extent the accumulation of tar is affecting the performance.

The means of removing tar differs considerably in different plants. Table 6 shows the gas-condensing and scrubbing equipment in use in the different plants. For convenience, the final tar-extracting apparatus in each case is printed in italics. It will be noted that the shavings scrubber appears to be the favorite tar-extracting equipment in water-gas plants, though the P. & A. tar extractor and the bubble washer are preferred in a few plants. The writers of this bulletin have had no opportunity to study the relative merits of these various types of apparatus under conditions which were comparable. As will be noted in the table, the amount of tar in the gas at the inlet of the purifiers varies considerably even with the same type of tar extractor, and it seems to be possible, under favorable conditions, to obtain practically complete extraction with any one of these

TABLE 6.—*Tar-Extraction Apparatus In Use.*

Plant	Kind o gas	% water gas	Lbs. tar per bu. oxide	Lbs. tar per million cu. ft. gas at box inlet at time o. insp.	Tar-removing apparatus	Temp. at box inlet at time of insp.	Remarks
						Degrees F.	
1	Water	100	2.81	13.2	Multi. Cond., Tray Scr., R. Hold. Mult. Cond., Pt. A., *Sh. Sbr.*	101	
2	Water	100	2.45	84.4	Scr., Cond, R. Hold., *B. Wash.*	121	R.Hold. has only one connection.
3	Water	100	6.33	81.4	Sc., P Cond., Sec. Cond. *Sh. Scr.*	130	
4	Water	100	1.62	252.0	Scr. 3 Mult. Cond. (Water) R. Hold., *Sh. Scr.*	123	2 shavings scrubbers installed since.
5	Water	100	1.32	17.2	[2]C. G.-Pri. Cond., P. & A., Scr., Cond., R. Wash., Lloyd Scr., W. G.-Multi-Cond., R. Hold., *P. & A.*	98	
6	Water	100	.67	24.8	Scr., 2 Cond., R. Hold., 2 *Sh. Scr.* (parallel)	86	
7	Water	100	4.40	9.7	R.Hold., 2 Cond., 3 *Sh. Scr.* (parallel)	90	
8	Water	100	.87	8.3	4 Cond. (parallel), R. Hold., *Sh. Scr.*	103	
9	Mixed	60	3.30	40.6	C. G.-P. C., *P. & A.*, Sec. Cond W. G-P. Cond., Sc., Sh. Scr., R. Hold., *P. & A.*	109	
10	Mixed	10	1.36	[1]13.6	C. G.-P. C., Sec. C., 2 Scr. W. G.-P. & A., R. Hold., *Sh. Scr.*	107 87	
11	Mixed	25	2.20	7.0 C. 10.8	C. G.-P. Cond., Sec. Cond., Wash. 2 Scr. W. G.-Cond., Scr., R. Hold., *P. & A.*	90	
12	Mixed	10–15	4.26	W. 2.2	G. G.-P. Cond., P. & A., 3 W. Cond., W. Scr., Rot. Scr. W. G.-R. Hold. Cond., *B. Wash.*	100 99	
13	Mixed	40	1.00	0.0	C. G.-2 P. Cond. (Air), Multi-Cond., Wash. Scr. Wash. *Sh. Scr.* W. G.-Cond, Scr., *Sh. Scr.*	100	
14	Mixed	5	3.27	C. 35.0	C. G.-P. Cond. P. & A., Wash., Scr., Int. Scr. Map.Wash. (Gas oil) W. G.-Sc. *Baf. Scr.*	86	
15	Mixed	40	.20	130.0	C. G.-P. & A., Multi. Cond. Coke Scr., B.-H. Wash. Scr. W. G.-Scr., R. Hold.	93	
16	Mixed	7	2.00	5.2	C. G.-2 P. Cond., 4 Multi. Cond., Bub. Wash. Rot. Scr. W. G.-Scr. R. Hold., P. & A.	80	

[1] Only coal-gas being run at the time.

[2] Coal-gas plant now shut down and apparatus being connected for use with water-gas.

Abbreviatons: P. Cond., Primary Condenser; Sec. Cond., Secondary Condenser; Scr., Scrubber; Sh. Scr., Shavings Scrubber; R. Hold. [illegible] Cond., Multitubular Condenser; Wash., Washer; Bub. Wash., Bubble Washer; Rot. Scr., [illegible] Intensive Scrubber; [illegible]

types of apparatus. At the time when the tar tests were taken, from which the pounds of tar, per million, as given in Tables 3 and 4, were computed, the temperature was very high. Hence, the results represent probably the most unfavorable conditions. The tar-extracting apparatus of many of the plants was overloaded at that time. The overload was due in some cases to inadequate apparatus and in others to the temperature of the cooling water in the various units being unavoidably high. It will be noted that where the temperature at the inlet of the purifiers is above 100°F. the amount of tar remaining in the gas is usually excessive, regardless of the apparatus, though this is not an invariable rule. The water-gas plants show higher average temperature at the purifiers than do the mixed-gas plants, and a comparison of the tar contents of the gases shows the average water-gas to contain about twice as much tar per million cubic feet as does the average mixed-gas. Where shavings scrubbers are employed, there seems to be in many cases no regular routine observed in regard to changing the shavings, and the indications are that in some cases they are allowed to remain unchanged too long. The frequency of changes would of course depend upon the tar content of the gas at this point in the system, and this in turn would be affected by the operation of the previous equipment. In one plant at least, notably Plant No. 7, a regular routine is observed, each bushel of shavings cleaning approximately 100,000 cubic feet of gas. It will be observed that the tar entering the boxes amounted to only 9.7 pounds per million cubic feet of gas. That this efficiency had not been realized at all times, however, is indicated by the previous column, which shows that spent oxide from this plant contained a rather high tar content of 4.4 pounds per bushel. On the other hand, some plants which at the time of the test showed high tar, give indications of better past performance, as judged by the analyses of spent oxide. It seems as though regular tests of the gas for tar by a tar camera or other device would be worth while in the better purifying results effected. It is, however, by no means common to find plants which possess the necessary apparatus but seldom use it. This subject deserves more consideration than is ordinarily given to it. It is probably safe to say, in spite of the difficulty in demonstrating to a certainty, that tar interferes with purification efficiency more than any other single cause.

METHODS OF REVIVIFICATION IN USE

Inspection of Tables 3 and 4 is likely to surprise advocates of revivification in place. It will be noted that whereas most of the straight water-gas plants introduce from 1 to 2 per cent of air into the gas prior to purification, the mixed-gas plants with one exception resort to the old method of revivifying oxide in the open air. Revivification in place has been in use for many years. Its theoretical advantages, especially under the now almost universal heating-value standard, are almost unquestionable. Why then is it not more universally used? One coal-gas operator, when questioned in regard to this matter, stated that his retort settings leaked so that enough air was admitted. Whether the leakage was really air or furnace gases was not demonstrable by any tests made in his plant. Other operators stated that so light a seal was carried on the hydraulic main that air was drawn in every time a retort was opened. While it is perhaps true that there is oftentimes considerable leakage of air or gas into the gas system, this is a most uncertain and doubtful way of revivifying in place, and possesses other disadvantages as well. When the retorts are leaky, it may be inadvisable for the time being to dilute the gas any further, but it would hardly seem reasonable that this uncertain method of introducing air is in vogue in a majority of the coal-gas plants. Other objections to revivification in place are frequently advanced, including the additional cost of enrichment to make up for the inert nitrogen introduced into the gas. Another objection frequently advanced is that the oxide has a tendency to cake very hard when revivification in place is tried. It is probably true that where an attempt is made to completely foul an oxide to its capacity with one handling, the caking will be pronounced, but it is believed that an attempt to carry revivification to this extreme is seldom practiced. Where caking has been found to occur with revivification in place, study should be given to the subject with a view to relieving this condition without abandoning revivification in place altogether. Some operators state that a lack of a proper amount of moisture in the gas is a fruitful cause of caking. An excessive loading of the material with iron, whereby the weight per bushel is greatly increased, might cause trouble, especially in deep beds of oxide. Under such conditions, consideration might well be given to the question whether the extra iron really pays for itself in amount of absorption obtained. It may be that a lighter oxide capable of revivifying rapidly might realize a considerably greater absorption in the long run. The carrier used may also be a factor in the case. If the carrier consists of planer chips, then consideration might well be given to the size of the chips; perhaps the particular size used packs too much, giving a better opportunity for the sulphur deposited during revivification to cement the particles of oxide together. The nature of the carrier is one of the objections which has been presented to the use of blast-furnace slag as a carrier for oxide. It is claimed by some that such oxide is especially likely to mat together, giving a product which is heavy and difficult to handle. It may be that this type of material might be objectionable in some cases.

Another reason why revivification in place is neglected to such an extent may be that it has been tried and that results do not bear out the performance expected. In such cases, it would be well to ascertain to what extent the introduction of air really affected the matter, and whether, as a matter of fact, the results might not have been due to other conditions.

Timidity about introducing air into the gas may be a cause of hesitancy on the part of some operators. It may be feared that the quality of the gas will be unduly affected, and that the general public may learn of the practice and misunderstanding the motive behind it, raise a clamor. There seems little real foundation, however, for such forebodings, as is evidenced by the fact that some of the best-operated plants have used the method for years without serious protest.

Revivification in the off-box was practiced in only one of the plants inspected, namely, in Plant No. 16. The cost of purification in this plant was lower per unit of hydrogen sulphide in the gas than in any other plant. A brief description of the method as applied in this plant may be helpful.

A box is blown shortly after it begins to show foul, as tested by lead acetate paper. At that time the box is usually removing about 60 per cent of the H_2S in the gas (this would, of course, depend a great deal upon the nature of the oxide). The rate of circulation of air through the box is about 2,000 cubic feet per minute (about double the maximum rate of gas flow). The air is blown through the box opposite to the direction of gas flow, just previous to the time of turning off the box. The air is not cooled during circulation, nor is any steam introduced with the air. This was tried at one time but resulted in warping the grids. Temperature observations are taken on the air as it leaves the box. The blowing is continued until a 20° F. rise in temperature is observed. At this point the fresh air supply is cut off and the deoxygenated air circulation is continued until a decided drop in temperature is observed. Some trouble from channelling and local heating has been experienced. The oxide is usually removed from the box only twice before final discard. The oxide has a tendency to cake harder with this method than without. Even with such difficulties as are encountered, the superintendent in charge considers it the most economical means of revivification. As has been mentioned in the detailed description of the purifying equipment of this plant previously given, the boxes in which this method of revivification is used are arranged for reversible flow, but there is only one sequence of boxes possible. The superintendent of the plant expresses the opinion that were the sequence of the boxes capable of alteration, together with the reversible flow, it would be possible to blow the boxes before they became very foul and that channelling and local heating troubles as well as caking of the oxide would be largely avoided.

While this opinion as expressed may be conjecture only, it accords quite well with the conclusions drawn by O. B. Evans in his paper, entitled "Revivification in place", already referred to.. It seems likely that the temperature rise during revivification dries out the oxide to a considerable extent and thereby favors caking. Were a surface condenser or other means used whereby the air would become thoroughly saturated with moisture during circulation, it seems likely that the caking would be diminished, since the water-saturated air would have a tendency to keep the oxide moist.

This method variously modified has been used for years by several large gas companies and from the experiences in the plant mentioned above it would seem to merit more attention from Illinois operators than it has received.

Even the practice of revivifying oxide in the open air could be improved in a number of cases. It is not uncommon for a considerable portion of the batch to overheat during revivification in the open, which, of course, has a detrimental effect on the sulphur-absorbing capacity of the material.

Revivification in place seems by far the preferable method. Its advantages might well be studied by those who are not now using it. The writers can do no better than to refer to O. B. Evans' paper, "Revivification in place", presented to the American Gas Association at their October, 1919, meeting. It is believed that the Association can supply copies of this paper for a few cents each.

LACK OF TESTS AND RECORDS

In every plant inspected by the writer, inquiries were made relative to the chemical control of purification practiced and the nature of the purifying records kept. It was rather surprising to learn how few operators really do make any systematic effort to study their purification problem from a technical standpoint. In a majority of plants the lead acetate paper test was the only sulphur test made aside from the total sulphur test on the purified gas, required by the Public Utilities Commission. About half of the plants visited possessed a Tutwiler apparatus, but in several cases the instrument was broken, or the stop-cocks were stuck, and in only one case which we recall were systematic tests made every day. The operators usually had only a hazy idea as to what their variouse purifiers were doing.

The purifying records were in many cases fragmentary and in a few cases kept on loose sheets of paper. In a few cases a separate oxide batch record was kept. The usual record showed the amount of gas passed by the first box of each sequence, between changes, and usually the purification of all this gas was credited to the first box. The sulphur content of the unpurified gas often varied considerably from day to day, but this was not taken into account in crediting a particular batch. The assumptions were really made, so far as the records went, that the H_2S content of the gas was uniform, and that the various batches as they came into first position would average up: viz., the first batch would receive credit for more than actual purification to offset the unearned credit given to other batches while they were in first position. In some plants analyses of spent oxides had been made, chiefly to value the oxides for cyanide recovery, and in such cases the sulphur per bushel was reported, but except in such cases, the records showed no figures from which the total sulphur absorption of a batch per bushel could be computed with any degree of accuracy. In the one plant where tests were regularly made and records kept of batch performance, it is interesting to note that the total cost of purification per 100 grains of H_2S in the gas to be purified is lower than in any other plant. In view of the small expenditure of time and equipment to gain this information it seems worthy of more consideration.

COST OF PURIFICATION

The ultimate criterion by which the gas operator judges purification performance in his plant is cost per 1,000 cubic feet of gas purified. So long as the sulphur content of the unpurified gas remains low and purification does not present an undue amount of difficulty from an operating standpoint, the operator is likely to be satisfied, provided the costs are reasonably low. It is when the necessity or advantage of using fuels of higher sulphur content presents itself or when the costs begin to mount that the average operator begins to inquire into purification efficiencies.

The cost figures given in Tables 3 and 4 are averages for 1919. Even a casual inspection of these figures in connection with the load and other conditions in the various plants shows that there is no direct relation between purifier load and purifying costs so far as can be ascertained from a comparison of different plants. Operating methods, size of plant, sulphur content of the gas, cost of labor, facilities for handling oxide to and from the boxes, cost of purifying materials (including freight), all have much influence on purifying costs. The only way to determine the effect of a single factor as purifier load, would be to make an extensive comparison of costs before and after an extension of the purifying system, care being taken to keep all other factors constant. The writers have no data from which any conclusions can be drawn relative to this point.

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Inspection of Tables 3 and 4 indicates that the average total purification cost in the mixed-gas plants (average about 25 per cent water-gas) is about one-third higher than the average cost for water-gas plants, but the sulphur content of the mixed-gas averages considerably higher than that of the water-gas plants. Calculated to a basis of sulphur absorbed per bushel of oxide, the cost of mixed-gas purification would probably be considerably lower than that of water-gas purification. The gas operator figures all his operating costs, including purification, to a basis of 1,000 cubic feet. While this is necessary in order to be in harmony with his other operating costs, purification results, especially in different plants, could be better compared on the basis of cost per pound of sulphur (or H_2S) absorbed per bushel of oxide. This could readily be determined from the purifying cost per thousand if the sulphur content of the oxide and the average H_2S content of the gas were known. Regular tests and a form of record such as is suggested in Appendix B of this paper would furnish the necessary information.

The operating cost is of course only a part of the cost of purification. The capital charges on the equipment are just as truly a part of the cost and in some cases they may approach the cost of operation. In making extensions to existing equipment, if greater efficiency of operation is the main thing sought, it is well to inquire whether the total purification cost will be decreased by the added equipment. A concrete example will serve to illustrate this. A certain plant in Illinois has a total annual gas output of about 550 million cubic feet of gas. Its present purifying capacity is 40,000 cubic feet per hour. The maximum hourly production is about 110,000 cubic feet. The purifying apparatus is therefore operating at about 275 per cent of its rated capacity. In spite of this heavy overload, the total purifying operation cost for 1919 was reported as only 0.7 cents per 1,000 cubic feet of gas purified. Great difficulty has been experienced in completely purifying the gas before distribution and therefore the management has let a contract for a new purifier which together with the necessary connections to tie it in with the existing boxes will cost about $18,000. The capital charges on the old equipment are not known and need not be considered, since these charges will remain as before, even after the new box is installed. Capital charges on the new investment will be about 14 per cent per annum, or $2,520. This amount will correspond to about 0.46 cents per 1,000 cubic feet of gas purified, which is considerably more than half of the total purifying operating cost per 1,000 for last year. It is obvious, therefore, that unless the purifying operating cost can be reduced to about 0.24 cents per thousand there will be no immediate financial gain from the new installation, though the company will be relieved from much of the anxiety under which it has been placed. This, while perhaps not expressible in dollars and cents, is worth considering. The purifying operating cost for 1919, namely, 0.7 cents per thousand, is lower than in a majority of plants of the same size, and it is possible that it is not absolutely accurate. There is often considerable difficulty, for example, in equitably distributing the cost of oxide purchased over a proper period of time. That such an error might have been present in this case is indicated by the fact that the purifying materials cost was only 0.2 cents per thousand, about one-fourth that in plants obtaining similar efficiencies. The labor cost, 0.5 cents per thousand, was somewhat higher than the average, as might be expected from the exceptionally overloaded conditions prevailing. The total purifying operation cost was therefore probably nearer 1.3 cents per thousand. The cost of removing, revivifying, and replacing the oxide was probably at least 5 cents per bushel. This would correspond to about 25 changes of oxide per year, or one change every two weeks. The gas purified per change was only about 10,577,000 cubic feet, or 4,800 cubic feet per bushel. The sulphur absorption was therefore only about 0.65 pounds per bushel per change. If the analysis of the spent oxide from this plant is typical of the perforance obtained, each batch probably had to be handled about eight times to get an absorption of 5.3 pounds of sulphur per bushel, and the oxide was discarded when it had taken up only about one-third as much sulphur as is usually absorbed in water-gas practice.

The new installation will increase the computed capacity from 40,000 cubic feet to about 117,000 cubic feet per hour. The arrangement will be such that there will be complete flexibility as to sequence of boxes and direction of flow. Other projected improvements should result in bringing gas containing much less tar than heretofore, to the purifiers, so that it will probably be possible to operate with much less handling of oxide. Assuming that each batch could be fouled to 35 per cent sulphur with two changes, this would amount, with the present sulphur content of the gas, to a removal and a replacement of about 7,800 bushels per year. At 5 cents per bushel for handling, the annual labor cost would amount to $390, or .07 cents per thousand. An average of about 3,900 bushels of oxide would be discarded per year. Assuming the cost of 40 cents per bushel of oxide f. o. b. the gas plant, this would amount to $1,560 per year or 0.29 cents per thousand. The total purifying operation cost then would appear to be about 0.36 cents per thousand, or about 0.94 cents per thousand less than the probable cost of purification for 1919, or 0.34 cents less than the reported cost. The total cost including capital charges will be about 0.82 cents per thousand. It seems then that after adding capital charges, even if operation as good as that assumed above is obtained, the company can hardly hope to purify the gas as cheaply as they reported last year. However, even after adding to the operation costs, the capital charges due to the new installation, they will save about 0.48 cents per thousand, as compared with the probable actual costs of operation last year. In arriving at these conclusions, some assumptions have been made which may or may not be accurate, but the example serves to illustrate the nature of the problem which faces the operator who contemplates an extension to his purifying system.

As has been previously mentioned, while extensions are undoubtedly needed in a number of cases, good operation may go a long way to offset insufficient equipment. On the other hand, cases have been observed where it seemed that a much over-size installation gave such a sense of security to the operator that his watchfulness was relaxed and he lost the opportunities for operating economy which his plant facilities would have permitted.

CONCLUSION

Though considerable improvement in purifying conditions in individual cases can be expected by application of the various suggestions which have been made, the process itself has inherent faults which cannot be avoided. It is cumbersome, requires heavy investment, and since it involves the handling of solid material must be costly in operation. Many gas engineers have looked forward to the day when some liquid purification process or some other process of similar theoretical merit would supplant oxide purification. Many such processes have been suggested and more than one has had promise of practicability. The fact remains, however, that millions of dollars are now invested in existing equipment for purifying gas by iron oxide. Oxide purifiers are continually being built to supplement those now in use, and even were a more economical process worked out for purifying gas, the replacement would necessarily be slow, since not all companies would be able to scrap existing equipment at once. Any study which will improve operation with present equipment is therefore worth while. It seems as though the greatest promise of material advancement in oxide purification generally lies in a more thorough knowledge of hydrated oxide of iron itself. Our knowledge of the material and the chemical and physical conditions affecting its performance is incomplete. Research work to bring forth this knowledge is needed. Standard testing methods by which the value of a particular material can be quickly and fairly judged are also needed. Until such studies are made, little radical advancement in the art of oxide purification is to be looked for.

A cooperation for carrying on this work has been entered into by the American Gas Association and the agencies of the Illinois Cooperative Mining Investigations and it is hoped that research work now in progress will solve some of the problems of oxide purification.

APPENDIX A

The Steere Engineering Company[1] formula for gas purifiers:[2]

$$G = \frac{3000 \times (D+C) \times A}{S}$$

or,

$$A = \frac{G \times S}{3000 \times (D+C)}$$

Where G=maximum amount in cubic feet of gas, corrected to 60°F., to be purified per hour.

S=factor for grains H_2S per 100 cu. ft. of unpurified gas, as given in table below.

D=total depth of oxide through which the gas passes consecutively in the purifier set, and is obtained by multiplying the depth of such oxide per box by the number of boxes in series in the set. Where a single catch box is used for two or more sets, disregard the catch box in obtaining the factor "D".

NOTE:—Duplex boxes, with two layers of oxide each and divided flow of gas, whereby half the gas passes through each layer, present the combined area of the two layers but the depth of one layer only to the passage of the gas. Therefore the area "A" of a duplex box is the sum of the areas of the two layers of oxide or double the cross-section of the box. The depth "D" is the depth of one layer of oxide per box multiplied by the number of boxes, in series, in the set.

A=cross-sectional area in square feet of the oxide through which the gas passes on its way through any one box, in series, of a set.

C=factor, 4 for two-box, 8 for three-box, and 10 for four-box series, respectively.

Where a single catch box is used for two two-box sets, use factor C=6.

3000=assembling constant.

Value of S is:

Grains H_2S per 100 cu. ft. unpurified gas	Factor
1000 or more	720
900	700
800	675
700	640
600	600
500	560
400	525
300	500
200 or less	480

---

[1] For detailed explanation see Gas Age, vol. 43, pp. 227, 1919, or Steere Eng. Co., Bulletin No. 37, 1919.

[2] Reprinted by permission of the Steere Engineering Company.

APPENDIX B

Sample record forms and computations for keeping account of oxide performance and the status of various oxide batches in use:

The following record forms are suggested only as embodying most of the essential features of a record which would give the gas operator a continuous knowledge of the performance of his purifiers. The absorption record is made out for a 3-box series but could of course be modified to suit the conditions in any given plant. The actual figures given are not meant to indicate just what absorptions would be obtained by each box; they are illustrative only. The remarks column could be enlarged to give ample space for other notes, such as when the direction of gas flow in a particular box was reversed. In the case illustrated the clean box is purposely put first and the rotation is backward, the successive sequences being A — B — C, C — A — B, A — B — C. This method might be applicable to any order desired. The time between changes of sequence in the illustrated form has no significance. In some cases several weeks might elapse between changes in sequence and months between refillings of a box. As stated, the illustration only suggests a form which the operator can adapt to his own needs.

Sulphur Absorption Record

Plant.. Month.......................................19....

Date	H_2S at purifiers inlet — Grs. per 100 cu. ft.	Box A		Box B		Box C		Gas purified for the day Corrected M cu. ft.	Lbs. H_2S absorbed			Remarks
		H_2S after box. Grs.	H_2S removed	H_2S after box	H_2S removed	H_2S after box	H_2S removed		Box A Batch 1	Box B Batch 2	Box C Batch 3	
1	125	20	105	10	10	0	10	2200	330	31	31	Order ABC
2	130	25	105	20	5	0	20	2120	318	15	60	
3	100	35	65	5	30	0	5	2272	211	97	13	
4	105	25	75	5	20	0	5	2310	248	166	16	
5	110	40	70	10	60	0	10	2005	200	172	29	
6	90	50	40	30	20	0	30	2736	156	78	117	
7	135	55	80	10	45	0	10	2500	286	110	36	
8	120	10	10	0	10	20	100	2234	32	32	320	Order CAB
9	105	5	10	0	5	15	90	2365	34	17	306	
10	95	5	5	0	5	10	85	2340	17	17	283	
11	120	5	20	0	5	25	95	2379	68	17	322	
12	100	10	20	0	10	30	70	2480	71	35	245	
13	125	15	20	0	15	35	90	2680	76	57	342	
14	100	5	40	0	5	45	55	2369	135	17	187	
15	95	15	30	0	15	45	50	2385	58	29	170	
16	90	0	5	15	75	5	10	2465	18	270	36	Order BCA
17	125	0	10	25	100	10	15	2542	36	363	54	
18	105	0	5	20	85	5	15	2434	17	290	51	
19	100	0	15	25	75	15	10	2505	54	270	36	
20	110	0	15	35	75	15	20	2675	57	285	76	
21	110	0	10	35	75	10	25	2430	35	260	87	
22	95	0	5	40	55	5	35	2395	17	187	119	
23	100	0	5	45	55	5	40	2480	18	198	144	
24	90	0	15	50	40	15	35	2562	55	146	128	
25	105	50	55	15	35	0	15	2645	208	132	57	Order ABC
26	110	55	55	10	45	0	10	2620	206	168	37	
27	115	70	45	15	55	0	15	2720	175	214	58	
28	130	75	55	15	60	0	15	2631	206	225	56	
29	95	Off	Off	15	80	0	15	2525		288	54	Box A off Order BC
30	100	15	85	10	5	0	10	2410	Batch4 293	17	34	Order ABC
31	115	20	95	5	15	0	5	2320	314	50	17	
	Tota	....	....	....	....	....	....	75734	Batch 1 – 3341 Batch 4 – 607	4203	3521	

NOTE:—The pounds of H_2S absorbed daily by each box are computed by multiplying the grains of H_2S removed by the box by 10 times the corrected volume of gas passing through the system and dividing the product by 7000.

Where a box is emptied during the month, the total absorption by that batch during the month up to the time of emptying could well be entered in the column, preferably in red ink. Likewise the number of the batch substituted for the batch removed should be entered in the same column ahead of the daily entries. The total absorption by each batch while in a box is entered in the batch record, a suggested form of which follows:

Batch Record

Batch No. .... *1* Kind of oxide.......*Natural* Bought from....................
Date purchased ...... *1-3-20* Wt. oxide per bu.........*25* Price per bu. (on ton).......*$20 ton*
No. bushels in batch.....*2500* Wt. new sponge per bu. (air dried).........*35*................

Date put into purifier	Box No.	Date taken out of purifier	Pounds H_2S absorbed	Equivalent lbs. sulphur	Lbs. sulphur per bu. oxide	Remarks
1 12 20	A	7/6/20......	23500	22100	8.85	
8 1 20	C	2/15/21.....	23000	21600	8.65	
3 16 21	A	8/17/21.....	20000	18820	7.54	41.0% sulphur
9 30 21	B	2/25/22.....	18000	16900	6.76	
3 15 22.......	C	6/20/22	8000	7540	3.01	Batch discarded
Totals ..			92500	86960	34.81	

% sulphur in spent oxide ....*49.5* % tar in spent oxide.......................................*2.0*
% cyanides ....

NOTE: If laboratory facilities are available, the percentage of sulphur in the oxide could be checked each time before the batch was returned to use. This would give more accurate total results than the sum of the Tutwiler tests, though the latter are very useful in enabling the operator to know at all times the condition of his purifying material. The sulphur equivalent to a given weight of H_2S is figured by multiplying the latter by 16 and dividing the product by 17. The batch throughout its usefulness should be accompanied by a batch number, preferably of metal, which is laid on the box cover or otherwise significantly placed while the batch is in the box and is stuck into or laid upon the batch while the latter is revivifying out of doors. The use of such a number will avoid mistakes as to the identity of a given batch.

The above forms could of course be printed in book form or made up as desired. The absorption record would require a page per month, while the batch record might well occupy a page per batch. The number of entries per batch would depend upon the practice in a given plant. Ordinarily one would not expect to handle a batch more than four or five times, perhaps less, but there are conditions which make many more handlings necessary. Any space remaining on the page after the entries might well be devoted to an extension of the remarks giving some information relative to the operating methods employed, rapidity of the material as to fouling and revivification, presence or absence of tar, fineness of the material before and after use, caking, etc. Also, if any laboratory tests of the material had been made prior to or during use, the agreement of these tests with practical results observed might eventually be valuable.

APPENDIX C

Determination of the further usefulness of a given batch of oxide, according to the formula[1] of Fulweiler and Kunberger:[2]

Average cost of purification =A¢ per M cu. ft. of gas
Cost of new oxide =B¢ per bushel
Residual value of old oxide =C¢ per bushel
Cost of removing, revivifying, and replacing =D¢ per bushel
Gas already purified by one bushel =E thousands of cu. ft.
Number of times oxide has already been used=F times
Average H_2S content per M cu. ft. =G pounds
Weight of one bushel of oxide =H pounds
Per cent of H_2S removed by test =I per cent
Capital charge per M cu. ft. =J¢ per M

Then

$$A=\frac{(B-C)+(F\times D)}{E}+J$$

But J is a constant (practically for such a problem) that does not affect this calculation, so we may write it:

$$\text{Operating cost}=(A-J)=\frac{(B-C)+(F\times D)}{E}$$

The question then, whether or not it will pay to use a batch again with any given absorption test I, depends upon whether

$$\frac{(B-C)+(F\times 1)D]}{E+\dfrac{H\times I}{G}}$$

is equal to; greater than; or less than the average (A—J). For the sake of a numerical example, let us assume that

$(A-J)=1.0¢$
$B=35.0¢$
$C=0$
$D=5¢$
$E=40.$ (M cu. ft. of gas)
$F=4$ times
$G=0.25$ lbs.
$H=50$ lbs.
$I=5\%$

Then

$$(A-J)=\frac{(35-0)+(5\times 5)}{40+\dfrac{(50\times .05)}{.25}}$$

---

[1] Used by permission of W. H. Fulweiler.

[2] Some of the phisical characteristics of ferric oxide: Proc. American Gas Institute, 1913, Vol. 8, Pt. I, p. 476.

so that using this batch would increase the average cost considerably. To get the minimum economical percentage that would just equal the average cost, we have—

$$I=\frac{G}{(A-J)\times H}\left\{(B-C)+[(F+1)\times D]-[(A-J)\times E]\right\}$$

Substituting the assumed values we obtain—

$$I=\frac{0.25}{(1\times 50)}\left\{(35-0)+[(4+1)\times 5]-(1\times 40)\right\}$$

$$I=.10 \text{ or } 10\%$$

In applying the above formula part of the information is known and the remainder may be obtained by test. For example, the monthly cost statement, if carefully prepared and correct, will give the value (A—J), viz., the purifying operating cost (includes purifying labor and purifying supplies per M). Invoices for purifying material purchased plus freight and handling into storage give the value B when figured per bushel. The value of C will be 0 in many cases, but if the oxide is sold or used in such a way that a money value can be assigned to it, then the value per bushel can be readily obtained. D may be estimated by keeping careful account of the cost of emptying a box, handling the oxide during revivification, and putting back in the box, and dividing by the number of bushels so handled. The value of E is not so definite, since a particular batch may be credited with some work done by other batches. If the plan for keeping account of oxide performance suggested in the text of this paper and illustrated in Appendix B is followed, no difficulty should be experienced, since the average H_2S content of the gas (in pounds sulphur per M) as recorded, divided into the pounds of sulphur absorbed per bushel by the oxide, will give the thousands of cubic feet of gas already purified. Or, if an analysis could be made for sulphur content of the oxide, the number of cubic feet of gas of average H_2S content corresponding to the sulphur per bushel could be readily computed. For example, assume that the air-dried oxide averaged 30 per cent sulphur, and that oxide weighed 50 pounds per bushel, the sulphur per bushel would be $.30\times 50=15$ pounds.

15 pounds=105,000 grains of sulphur, or

$$\frac{105{,}000\times 34}{32}=112{,}000 \text{ grains } H_2S.$$

If the average H_2S content of the gas is 100 grains H_2S per 1 cu. ft., then this gas purified by the oxide per bushel is

$$\frac{112{,}000}{1}=112{,}000 \text{ cu. ft.}$$

The number of times the batch in question has been used, F, can also be quickly ascertained from the batch record as illustrated in Appendix B. G., the average H_2S content per M cu. ft. can readily be obtained from the record referred to over any period of time. The average content in grains per 100 cu. ft. is multiplied by 10 and the product divided by 7,000 to convert grains to pounds. The weight per bushel of oxide, H, can probably be obtained with sufficient accuracy by spreading out and air-drying a bushel of oxide made up from samples taken from all parts of the batch and then weighing on a good scale. The value of I has to be obtained by a laboratory test. The apparatus employed (aside from a chemical balance, which is essential) is shown in the accompanying sketch, Figure 5.

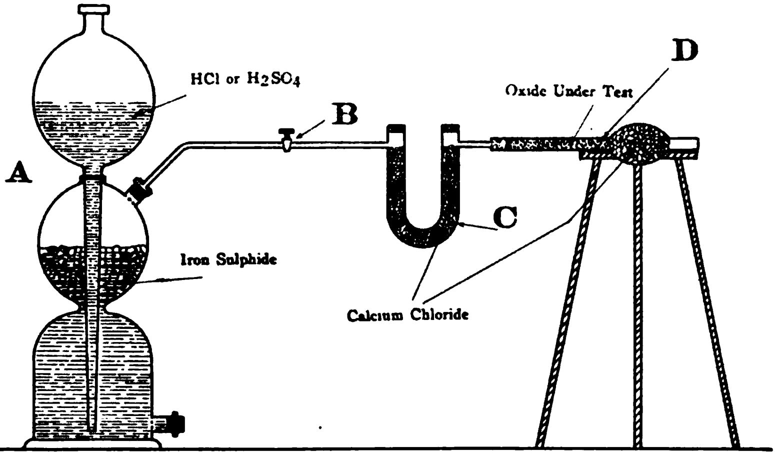

FIGURE 5—Kunberger apparatus for testing oxides for gas purification. A is a Kipp gas generator. B is the stop cock controlling the generation and flow of gas. C is the drying tube. D is the tube containing the oxide under test and calcium chloride for absorbing the water liberated.

In the sketch, A is Kipp gas generator made of glass in which H_2S is generated by the action of hydrochloric acid or dilute sulphuric acid on ferrous sulphide. The generation and flow of gas is controlled by the stop-cock B. The U-tube C contains granulated fused calcium chloride to dry the H_2S. The calcium chloride tube, D, contains in the straight part of the tube, 5 grains of the oxide to be tested, mixed with about 2 grains of coarse sifted sawdust, followed by granulated fused calcium chloride in the bulb of the tube. Little wads of glass wool are placed in the ends of this tube and between the oxide and the calcium chloride to retain the materials in their proper places and prevent any from dropping out while weighing. Where sponge, viz., mixed oxide, is to be tested, no sawdust is mixed with the samples. A coarsely ground sample of the sponge is used. Care must be taken to get a truly representative sample.

After the tubes are filled, D is weighed on a chemical balance. Then it is connected to the apparatus, as shown, and dried. H_2S is passed through it slowly for one hour. During the reaction H_2S is decomposed by the oxide and water is formed. The water formed is retained by the calcium chloride in the bulb of the tube therefore, the gain in weight of the tube during the time gas is passing through the tube is the weight of the tube during the time gas is passing through the tube is the weight of the H_2S absorbed, and the percentage is computed by dividing this gain in weight by the weight of the sample taken for test.

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DIVISION OF THE
STATE GEOLOGICAL SURVEY
FRANK W. DE WOLF, Chief

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COAL RESOURCES OF DISTRICT IV

BY

GILBERT H. CADY

ILLINOIS MINING INVESTIGATIONS

Prepared under a cooperative agreement between the Illinois State Geological Survey Division, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines

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COAL RESOURCES OF DISTRICT IV

By Gilbert H. Cady

PART I.—GEOLOGIC RELATIONS IN DISTRICT IV

INTRODUCTION

IMPORTANCE OF THE AREA

District IV of the Illinois Cooperative Investigations (Fig. 1) includes that part of the central portion of the State in which the coal production is from the No. 5 or Springfield bed. Within the district lie those counties having a large production from No. 5 coal, namely, all of Peoria County, a large part of Fulton County, and the part of Sangamon County north of Chatham; and in addition other counties or parts of counties which produce smaller amounts, or are at least underlain by this coal, namely, Cass, Christian, Dewitt, Knox, Logan, McLean, Macon, Mason, Menard, and Tazewell. From the entire district in the year ending June 30, 1920, over 11 million tons were produced from the No. 5 bed. Among the districts of the Cooperative Investigations this one ranks third in order of production. In area it ranks second, and in amount of workable coal present possibly first. The quantity produced since 1881 approximates 140 million tons from No. 5 coal, a tonnage which represents only a small per cent of the coal originally present in the area.

The present report is one of a series on the geology of the coal-bearing rocks and on the coal resources of Illinois. The coal field has been subdivided into districts for convenience, study, and description, the basis for the subdivision being stated in the preliminary bulletin[1] of the series. The outlines of the various districts are indicated on the accompanying sketch map (Fig. 1).

ACKNOWLEDGMENTS

As has been the case with earlier reports in the series, this bulletin represents compilation of material secured from various sources.

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[1] Preliminary Bulletin Illinois Coal Mining Investigations, p. 12, 1913.

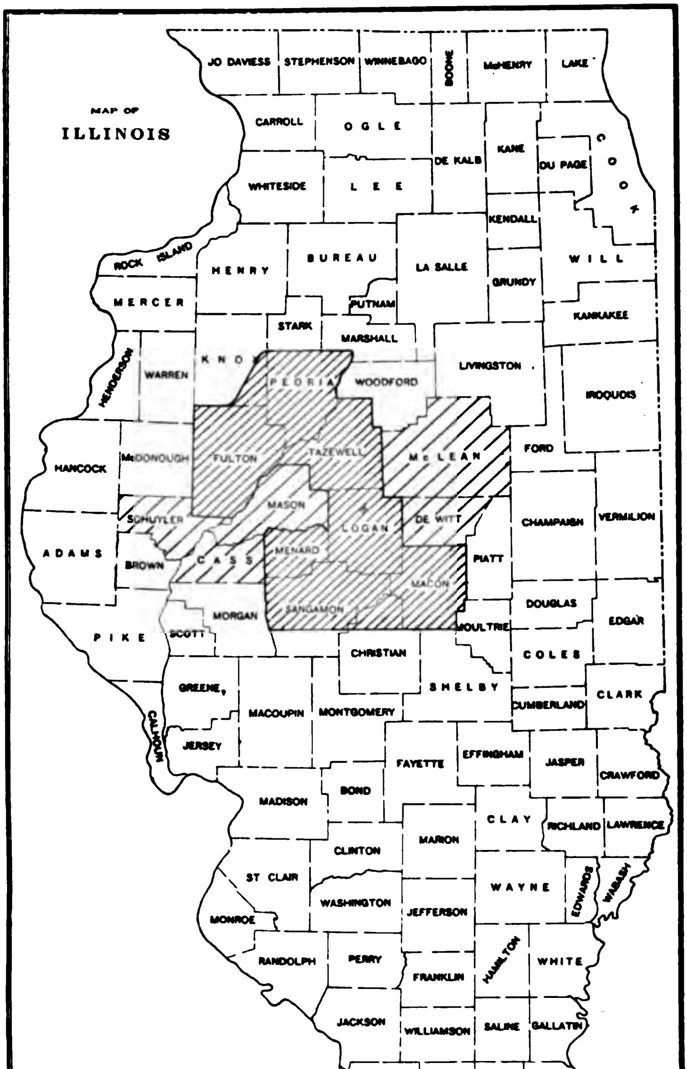

FIG. 1.—Map showing extent of District IV and an adjacent area covered in the report.

Reports on the three important coal-mining areas in the district, namely those in Fulton, Peoria, and Sangamon counties, have already been published and another is in manuscript form.[1]

Acknowledgment is herewith made of a large use of the material presented in these reports, considerable parts of which are directly quoted. Of special assistance have been the field notes of members of the Investigations, especially those of K. D. White and F. H. Kay. The miscellaneous notes of J. A. Udden, F. F. Grout, W. F. Wheeler, Thomas Moses, T. E. Savage, and others have also been of great assistance.

The availability of drill and shaft records and the information collected in the mines is due to the courtesy of the operators and miners in the district. Grateful acknowledgment is made of the Survey's indebtedness to the kindness and generosity of those in a position to give information necessary for its work in connection with the coal mining industry in this and other districts.

GEOGRAPHY

TOPOGRAPHY AND GLACIAL DRIFT

District IV is an area of undulating plain which slopes toward the valley of the Illinois. Much of the area is monotonously level, the Illinois valley being the single important interruption in the continuity of the plain. This valley has a depth of about 200 to 250 feet between Peoria and Chillicothe.

The surface of central Illinois is essentially as left by the last retreating glacier, deposits from which filled up and obliterated all surface indications of valleys and other irregularities which existed in the rock surface prior to glacial time. Within certain lobate belts 2 to 10 miles in width which mark stationary positions of the ice front for long periods, thicker amounts of material accumulated in ridges known as glacial moraines that rise 100 feet or more above the adjacent bordering plains and that are rolling and irregular in profile. The "drift," as the material left by the ice is called, is commonly thicker beneath

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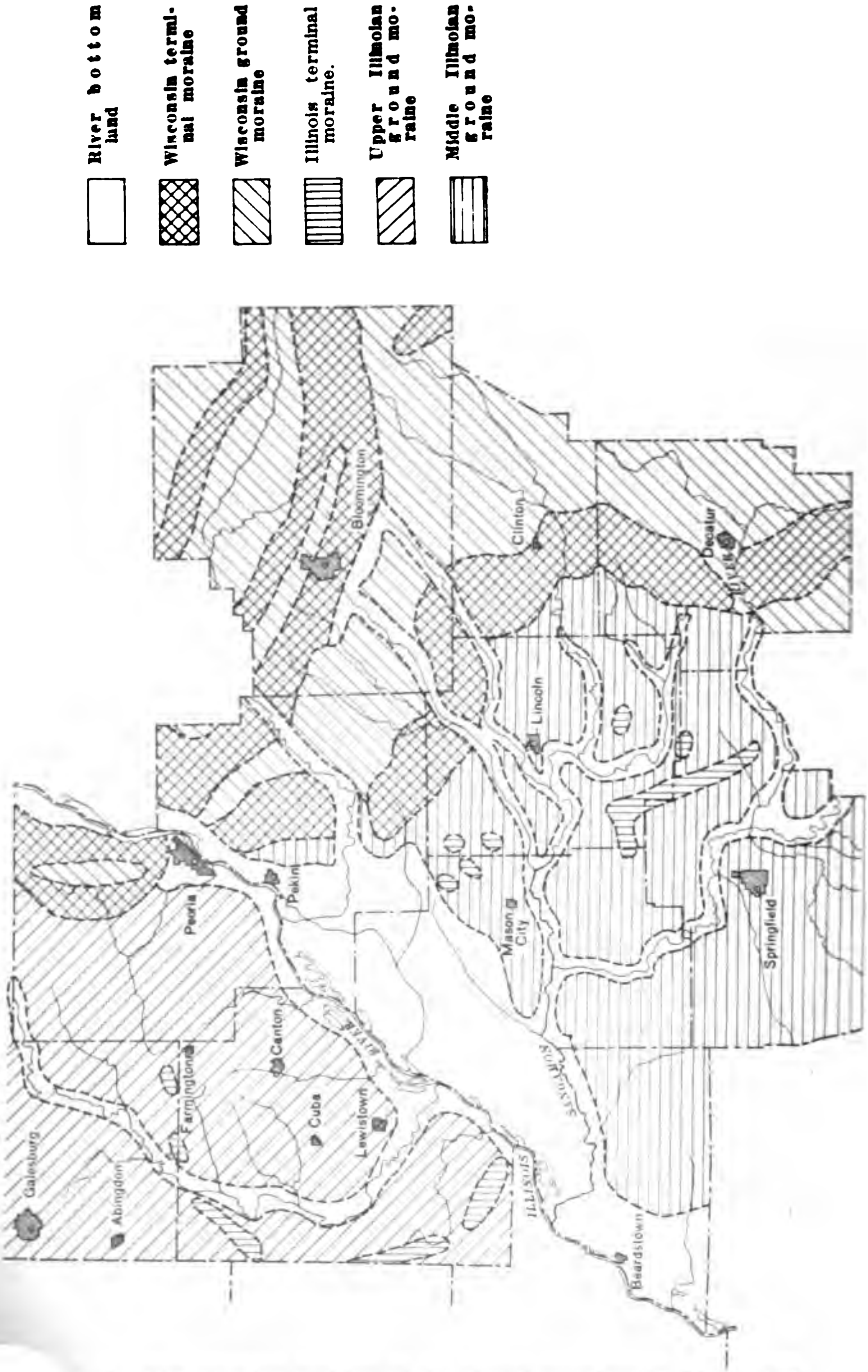
[1] Shaw, E. W., and Savage T. E., U. S. Geol. Survey Geol. Atlas, Tallula-Springfield folio (No. 188), 1913.

Udden, J. A. Geology and mineral resources of the Peoria quadrangle, Illinois: U. S. Geol. Survey Bull. 506, 1912.

Savage, T. E., Geology and mineral resources of the Springfield quadrangle: Illinois State Survey Bull. 20, p. 97, 1915.

Savage, T. E., Geologic structure of the Canton and Avon quadrangles: Ill. State Geol. Survey Bull. 33, p. 91, 1916.



G. 2.—Map showing position of the glacial moraines in District IV.

the moraine than beneath the plains, and the height and position of the moraine seems not to be controlled by the relief of the bed rock.

Students of glacial geology in Illinois have mapped two moraines crossing District IV east of the Illinois (Fig. 2), the two uniting north of Peoria and running as a single ridge of thick drift parallel to and west of the Illinois valley through northeastern Peoria County and western Marshall County, to and beyond the boundary of the district. East of the Illinois, one ridge, known as the Shelbyville moraine, swings in lobate curves southward through central Tazewell, eastward through northeast Logan, south through eastern Dewitt and central Macon counties into Shelby County. Clinton, Decatur, and Shelbyville are located on or near this moraine, as are also the villages of Macon, Harristown, Warrensburg, Hallsville, Waynesville, Atlanta, and Delavan. Throughout much of its course the moraine rises ordinarily 75 to 100 feet above the plain and stands out in bold relief when viewed from the south or outer border. "From the north the relief is less noticeable, and is more pronounced for a few miles north and south of the Illinois River than elsewhere in its course, but even there scarcely exceeds 75 feet."[1] The moraine has a breadth of several miles, averaging six to eight, but in places as much as twelve.

The relief of the Shelbyville moraine is a rough indication of the increase in thickness of the drift along the ridge as compared with its thickness on the plains within and without the moraine. In other words, along these ridges a greater thickness of unconsolidated surface material must be penetrated in drilling or shaft sinking than off the ridges. The following table shows the depth to the rock at a number of places along the Shelbyville moraine.

Thickness of drift along the Shelbyville moraine

	Feet
Findlay	**168**
Windsor, Shelby County, more than	**127**
Macon	**170**
Decatur	**140**
Maroa	**273**
Clinton	**352, 261**
Atlanta, more than	**200**
Delavan, more than	**300**

The foregoing figures may well be compared with the following, which show the drift to be much thinner at certain places south and west of the moraine.

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[1] Leverett, Frank, The Illinois glacial lobe: U. S. Geological Survey Monograph 38, p. 194, 1899.

Thickness of drift south and west of the Shelbyville moraine

	Feet
Shelbyville	27
Tower Hill	31
Blue Mound	75
Niantic	82

The northern morainic belt extending from Peoria through McLean County is known as the Bloomington moraine. Its relief on the southern border seldom falls below 50 feet; the average relief is probably 75 or 100 feet. In Tazewell County the surface south of the moraine varies in altitude from 650 to 725 feet, whereas the crest of the moraine has an altitude varying from 700 to 825 feet above sea level. In McLean County the outer border varies in altitude from 700 to 820 feet and the crest from 775 to 913 feet above sea level.

Along the Bloomington moraine as along the Shelbyville ridge, the drift is much thicker than in the bordering plains. In one shaft at Bloomington 254 feet of drift were encountered and 358 feet in another. Some of this difference is no doubt due to irregularity in the bed-rock surface. At Saybrook a drilling passed through 247 feet of drift and at Washington in Tazewell County 335 feet.

East and north of the moraine in Woodford County at Eureka the drift is 151 feet in thickness. In general, it is believed to be thinner than along the ridge, by an amount just about equivalent to the relief of the moraine. At the position of preglacial depressions or valleys, the distribution and direction of which are independent of the position of the moraines, the drift is always exceptionally thick, in the plain as well as along the moraine.

The thickness of glacial material has an important bearing on mining operations because shaft sinking is commonly more difficult through unconsolidated material of glacial origin than through rock. Especially is this true if the drift is thick and made up in part of beds of water-bearing gravel, as is commonly the case. For instance, in a drilling near Washington in Tazewell County, the lower 128 feet of the 335 feet of drift present is described as sand, quicksand, and gravel. The possibility that a considerable amount of such material may be present makes it very important to determine the character of the drift to the rock, before locating a shaft near or in one of the morainic belts. A definite knowledge of the position and trend of the various large preglacial valleys would be of much practical value, as where these exist the drift is commonly made up of a larger proportion of loose, water-bearing material than it is elsewhere. Unfortunately this information is not available except for small areas in the district where detailed field examinations have been made.

TRANSPORTATION AND MARKETS

Except as the relief of the country reflects changes in the character and thickness of the drift or other surface material, physiographic factors in Illinois exercise little control over the coal industry. To a certain extent, however, the Illinois valley is a barrier separating the coal lands in Schuyler, Fulton, Peoria, and Knox counties from those east of the river. As a result the market for coals west of the river has been more largely to the west than is the case with coals east of the river. Within each part of the district communication is easy and railroads numerous. The western portion is, however, less fortunate than the eastern because it is served by fewer railroads, is more dissected by streams, and is not everywhere so readily accessible. In general, however, the district is in close touch by railroad with Chicago, St. Louis, and the markets of the northwest.

The importance to the coal industry of Illinois River as a means of river transportation for the district may well be pointed out. The coal mines of Peoria and Tazewell counties are especially accessible to barge traffic and it is not improbable that with improvement Sangamon River could be made suitable for water transportation as far upstream as Petersburg, Menard County, and possibly even to Springfield. It is possible likewise that Spoon River could be used in the same way for some distance above its mouth. This is a transportation resource of great potential usefulness which at present is almost entirely neglected, as only one mine in the area, namely that at Lancaster Landing is equipped with facilities for barge loading.

TOWNS

Several important cities and many smaller towns and villages lie within the area. Springfield, Peoria, Bloomington, Decatur, Clinton, Canton, Lincoln, and Pekin are the larger cities of the district. In each of these communities except Clinton the coal-mining industry has been an agent contributory to its growth.

USE OF DRILL RECORDS

Exploration work with the drill has been carried on much less extensively in this district than in other districts of the State with the exception of District III to the west. It is important, therefore, that the Survey be furnished with the results of all new drilling in this district; especially is this true in Menard, Logan, and Dewitt counties, where there has been so little drilling that the stratigraphic succession remains in considerable doubt. Records of drilling should be supplied so far as possible, and the examination by members of the Survey of churn-drill cuttings and diamond-drill cores is highly desirable. Upon request cloth sacks in which cuttings can be saved, will be furnished drillers or operators using the churn-drill in exploration work. After 40 or 50 of the sacks have been filled they may be forwarded to the State Geological Survey, Urbana, by express collect. It is highly desirable that operators arrange for such study as outlined in connection with contemplated drilling operations. Drill cores are the best means of studying the formations in a drift-covered area of flat-lying rocks like Illinois, and through the cooperation of operators it has been possible for the Survey to obtain such cores from a number of places in the State for examination in this office. One core has been furnished from this district, coming from a well located just south of Springfield, and it is hoped that opportunities will arise of obtaining others at various localities in this district. Upon request the Survey will furnish boxes suitable for the shipment of diamond-drill cores.

ROCK FORMATIONS OF DISTRICT IV

COAL-BEARING ROCKS

GENERAL DESCRIPTION

The coal-bearing strata in Illinois belong, with unimportant exceptions, to what is known as the Pennsylvanian system of strata, so called because the system is very completely represented by the coal-bearing strata of that State. This system is also commonly called the "Coal Measures," a name which will be used frequently in this report. The Pennsylvanian strata are underlain by strata of various ages; in the southern part of the district by rocks of Mississippian age, the next preceding system; and in the northern part of the coal basin by rocks of still older systems, specifically of Devonian and Silurian age. These relationships are shown in figure 3. In District IV the northern boundary of the Mississippian rocks below the "Coal Measures" runs east and west, north of Peoria and Bloomington, and Devonian or possibly Niagaran strata underlie the Pennsylvanian rocks north of the Mississippian boundary to some distance north of the boundary of the district. The Pennsylvanian system is overlain by the unconsolidated clays, sands, and gravels which constitute the glacial drift, as explained in an earlier section of the bulletin, or by river deposits. Without this covering the coal-bearing beds would form the surface material for the entire area considered in this report.

The strata of the Pennsylvanian or 'Coal Measures" system consist of shales and sandstones, and minor amounts of limestone, clay, and coal. The system thickens gradually toward the southeast part of the State, where it attains a thickness of about 2,000 feet. In this district the greatest known thickness of the "Coal Measures" is along its south boundary in Macon County, where the base of the Pennsylvanian lies at a depth of about 1,100 feet, with drift of variable thickness up to about 200 feet at the surface. In the western part of the district the Pennsylvanian or "Coal Measures" strata have a thickness of only about 200 feet or less, the thinning being largely due to the gradual rising of the strata in that direction, the upper beds being planed off or truncated by erosion. In the northern part of the area the base of the Pennsylvanian rocks lies at a depth of between 300 and 600 feet, depending upon the altitude of the surface.

Shales comprise the greater part of the strata and vary, on the one hand, through sandy shales to sandstones, and on the other,

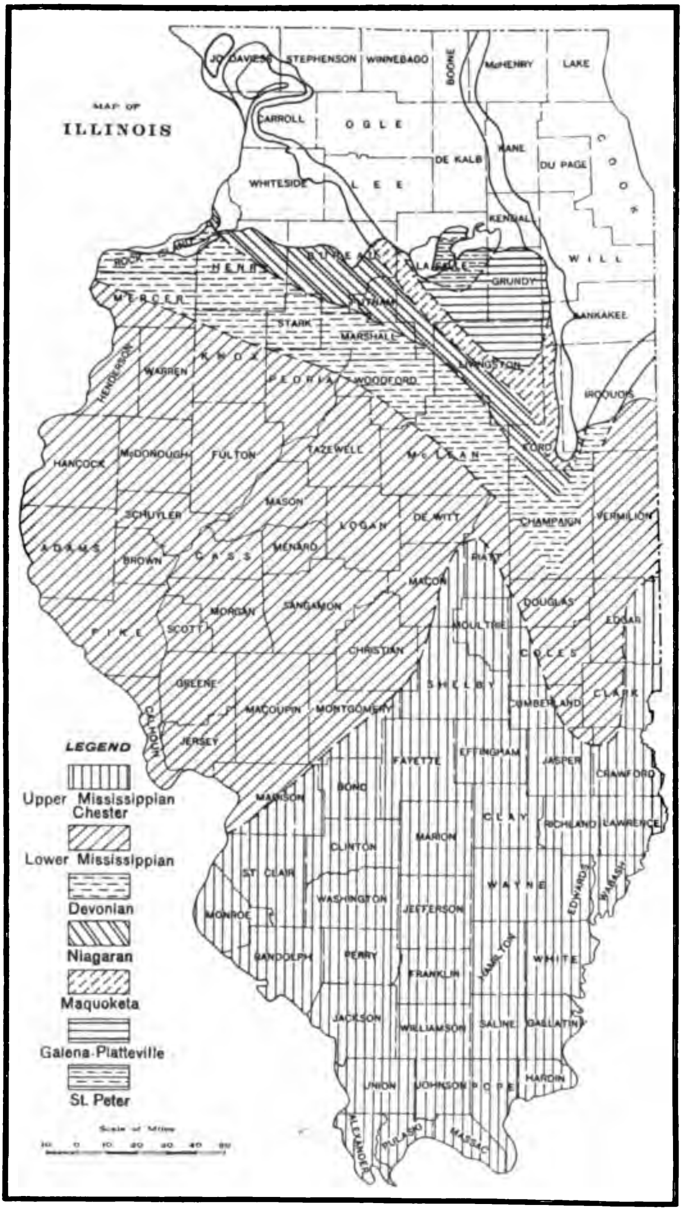

FIG. 3.—Map showing the areal geology of the surface upon which the Pennsylvanian strata were deposited.

(*Preliminary*)

through limy shales to limestones. A commonly occurring grayish, fine-grained, well-laminated shale, which is very slippery when wet is called "soapstone" by the miners. Hard gray shale with well-develloped laminae goes under the name of "slate," especially if its color is dark or black. Shale containing a considerable amount of limestone distributed irregularly may receive the name "lime shell" or simply "shell" from the miner or driller. "Niggerheads" are concretionary masses of lime and iron pyrites or lime alone, having more or less concentric structure, which are found in some of the "Coal Measures" strata. Such concretionary nodules or masses are commonly found in the roof shale of the No. 5 (Springfield) coal in this district.

Sandstones are prominent at several horizons in the Pennsylvanian. The system commonly terminates at the base in a coarse sandstone, especially in the western part of the district. Other sandstones are rather widespread about the middle of the system. These beds are generally lenticular in cross-section and some, especially in the vicinity of Peoria, seem to be in the nature of channel deposits of rather local distribution; accordingly, the sandstones cannot be identified with much certainty from drill hole to drill hole, particularly when the drilling is as scattered as it is in this district. The sandstones are commonly fine-grained and micaceous, with numerous fragments of coaly material embedded in them, which represent logs, branches, or pieces of wood which were buried in the sand.

The limestones, although constituting but a small part of the "Coal Measures," are nevertheless stratigraphically important, as they furnish a means of identifying strata with which they are associated. Several horizons have been identified and traced over a large part of this and adjoining areas. One of these is the cap rock of No. 6 coal which is commonly found less than 30 feet above the coal. In a few places this limestone is reported to rest directly upon the coal, but most commonly it is separated from the coal by a few feet of shale. A limestone known as the Lonsdale in the Peoria district and as the Rock Creek in the Springfield district seems to be widespread in District IV. This limestone is found about 100 feet above No. 6 coal in Peoria County and about 75 feet above the coal in the Springfield area. It has been traced west into Fulton County, north into Bureau County, and northeast into Livingston and LaSalle counties. In the southern part of the district two limestones are found in the interval lying between 200 and 300 feet above No. 6 coal. The lower is known as the Carlinville and the upper as the Shoal Creek limestone. Where only one of these limestones is recorded by the driller it is not always possible to determine which one is present. In the Springfield region a limestone known as the Crows Mill limestone, found about 230 feet above No. 6 coal, may correspond either to the Carlinville or to the Shoal Creek limestone. The New Haven limestone, which lies about 500 feet above No. 6 coal, and is of rather wide distribution in the southern half of the coal basin, is not known to underlie any of this district except possibly southern Macon and northern Christian counties.

Fire clays are normally associated with coal beds. Fire clays at or near the top of the Pottsville formation have some economic importance in the western counties of this district, chiefly in Schuyler and Fulton counties, but these clays are of still greater importance west of the district.

DIVISIONS OF PENNSYLVANIAN SYSTEM

For convenience of study, the coal-bearing beds of Illinois have been separated into the following divisions, each of which is called a formation. The formations are numbered in the order of age and deposition:

3. McLeansboro
2. Carbondale
1. Pottsville

POTTSVILLE FORMATION

GENERAL DESCRIPTION

The Pottsville formation, the oldest division of the "Coal Measures" rocks, consists of a succession of sandstones, shales, and thin coals, all of which lie below No. 2 coal. The beds were deposited upon an old land surface and consequently are variable in thickness and character. Furthermore, these deposits were apparently made in a rising sea, in a relatively shallow basin, so that the upper beds of the formation are more widespread than the lower, and the formation becomes thinner toward the border of the coal field.

Information concerning the Pottsville in this district is based upon exposures in Schuyler and Fulton counties and a few drillings in Fulton, Peoria, Sangamon, Logan, Macon, and McLean counties. The log of one of these drill holes, located half a mile southwest of Springfield in the S.E. ¼ sec. 5, T. 15 N., R. 5 W., supplies the most reliable section of the Pottsville formation in the Survey files. The drillers' record of this hole, together with the core, was turned over to the Survey. The log, verified and revised from the core by T. E. Savage, is given below and is shown graphically on Plate II:

Log of boring half a mile southwest of Springfield, in the S. E. ¼ sec. 5, T. 15 N., R. 5 W.[1]

Description of Strata	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Quaternary system				
Pleistocene and Recent—				
Clay and gravel	34	....	34	....
Pennsylvanian system—				
McLeansboro formation—				
Coal (No. 8)	1	6	35	6
Clay shale	4	....	39	6
Shale, fine, gray, micaceous, sandy	5	....	44	6
Sandstone, fine grained, gray	5	6	50	....
Shale, sandy, micaceous	15	....	65	....
Shale, fine, sandy, micaceous, with many dark carbonaceous spots	45	....	110	....
Shale, dark	....	3	110	3
Shale, bluish, micaceous	17	4	127	7
Shale, dark bluish, fossiliferous	2	....	129	7
Shale, dark blue	3	3	132	10
Shale, black, coaly (No. 7 coal)	....	2	133	....
Clay shale, light gray	10	5	143	5
Shale, gray, with red bands and blotches	6	5	149	10
Limestone, gray argillaceous	1	4	151	2
Shale, gray	4	10	156	....
Shale, dark	5	....	161	....
Shale, yellowish, calcareous	4	11	165	11
Limestone with *Fusulina*, *Reticularia*, *Seminula*, and *Productus semireticulatus*	6	9	172	8
Shale, blue to gray	3	....	175	8
Carbondale formation—				
Coal, Herrin (No. 6)	....	6	176	2
Shale, bluish gray	4	....	180	2
Shale, light gray	1	10	182	....
Shale, gray, calcareous	3	3	185	3
Shale, gray	24	....	209	3
Limestone, gray, shaly	....	10	210	1

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[1] U. S. Geol. Survey Folio 188, p. 2, 1913.

Log of boring half a mile southwest of Springfield—Continued

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Shale, black, fissile, with *Orbiculoidea* and other fossils	4	6	214	7
Shale, black, shelly, pyritiferous	....	6	215	1
Coal, Springfield (No. 5)	6	4	221	5
Shale, gray (fire clay)	6	8	228	1
Shale, bluish	6	....	234	1
Shale, black	3	4	237	5
Shale, gray	3	8	240	1
Shale, grayish blue to yellow	35	2	275	3
Coal (No. 4)	2	8	277	11
Shale, gray, impure (fire clay)	1	....	278	11
Shale, black, carbonaceous	....	8	279	7
Shale, dark	20	5	300	....
Shale, blue	31	....	331	....
Shale, black	2	....	333	....
Coal (No. 3)	1	6	334	6
Shale, clay	12	6	347	....
Shale, bluish gray	15	....	362	....
Shale, black	1	4	363	4
Coal	....	3	363	7
Shale, blue	2	5	366	....
Shale, sandy, micaceous	5	6	371	6
Shale, bluish	5	....	376	6
Shale, gray	2	....	378	6
Sandstone, shaly, micaceous	11	6	390	....
Shale, bluish	1	....	391	....
Sandstone, coarse grained, micaceous	9	....	400	....
Shale, dark, micaceous	7	....	407	....
Clay shale	1	....	408	....
Shale, brown, with hard bands	5	....	413	....
Coal } Coal (Murphysboro or No. 2)	1	3	414	3
Dark shale	3	11	418	2
Coal	....	10	419	....
Pottsville formation—				
Shale, blue	8	....	427	....
Shale, dark	10	....	437	....
Clay shale	2	....	439	....
Shale, dark gray	12	2	451	2
Coal	1	4	452	6
Shale, dark gray	6	6	459	....
Shale, black	4	....	463	....
Shale, gray	6	....	469	....
Shale, black	5	6	474	6
Shale, light gray	1	6	476	....
Shale, dark, slickensided	....	6	476	6

Log of boring half a mile southwest of Springfield—Continued

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Shale, light	3	6	480	....
Shale, dark	49	....	529	....
Shale, sandy	15	4	544	4
Shale, light blue	1	....	545	4
Shale, dark blue	1	....	546	4
Shale, light, clayey	7	....	553	4
Shale, black	1	....	554	4
Coal (No. 1?)	....	10	555	2
Shale, black	24	10	580	....
Sandstone, coarse, carbonaceous, in places micaceous	13	....	593	....
Sandstone	1	....	594	....
Shale, dark	27	....	621	....
Shale, light	4	....	625	....
Shale, black	2	4	627	4
Shale, conglomeratic, carbonaceous, and gray sandstone	23	2	650	6
Shale, dark	6	....	656	6
Shale, conglomeratic, dark, and sandstone interlaminated	4	10	661	4
Sandstone, coarse, brown to gray	36	2	697	6
Mississippian system—				
St. Louis and Spergen limestones—				
Limestone	12	6	710	....
Shale, hard, light colored	2	....	712	....
Limestone, light gray, argillaceous, somewhat conglomeratic	11	....	723	....
Limestone, argillaceous	11	....	734	....
Limestone, impure, argillaceous	26	....	760	....
Shale, gray, in places calcareous and somewhat conglomeratic	15	....	775	....
Limestone, gray	7	....	782	....
Shale, bluish, variable and somewhat calcareous	10	....	792	....
Limestone, impure, gray, in places with argillaceous bands	16	....	808	....
Limestone, gray	20	....	828	....
Limestone, arenaceous	14	....	842	....
Limestone, dark, sandy	8	....	850	....
Shale, impure	2	....	852	....
Shale, calcareous	9	....	861	....
Limestone, impure, shaly, and in places sandy	35	....	896	....
Limestone, white	5	....	901	....
Limestone, sandy or shaly	12	....	913	....

Log of boring half a mile southwest of Springfield—Concluded

Description of Strata	Thickness		Depth	
	Ft.	In.	Ft.	In.
Warsaw and Keokuk formations—				
Shale, calcareous	14	....	927	....
Shale, blue	5	6	932	6
Shale, sandy	3	4	935	10
Shale, blue	2	2	938	....
Shale, dark	4	....	942	....
Limestone	1	....	943	....
Shale, gray	12	....	955	...
Shale, blue	6	....	961	....
Shale, sandy	3	....	964	....
Sandstone	1	....	965	....
Shale, sandy	2	3	967	3
Sandstone	3	9	971	....
Shale, sandy	14	6	985	6
Shale, bluish gray	19	6	1005	....
Shale, hard, gray	15	....	1020	....
Shale, hard, bluish gray	33	4	1053	4
Limestone, oolitic	3	8	1057	....
Shale, blue	6	....	1063	....
Shale, blue, with limestone bands	14	....	1077	....
Burlington limestone—				
Limestone, hard, with chert bands	4	....	1081	....
Limestone, hard, gray	20	....	1101	....
Limestone	9	....	1110	....
Limestone, broken, cherty	15	....	1125	....
Limestone, cherty	7	....	1132	....
Chert	10	6	1142	6
Limestone, cherty, with *Spirifer grimesi* and other fossils	16	....	1158	6
Chert, with some limestone	9	....	1167	6
Limestone, with some chert	16	....	1183	6
Kinderhook group—				
Limestone, reddish, shaly, in places cherty	43	6	1227	....
Limestone, gray, with chert bands	14	....	1241	....
Shale, greenish	11	....	1252	....
Shale, hard, greenish gray	34	....	1286	....
Shale, bluish gray, upper part with zones of fine-grained oolite	53	....	1339	....
Devonian system—				
Shale, black or very dark, with *Sporangites*, *Lingula*, etc., common	133	....	1472	....
Limestone, gray	28	....	1500	....

STRATA COMPRISING THE POTTSVILLE FORMATION

The rock at the base of the Pottsville formation is commonly a coarse-grained sandstone. Such a sandstone is present in the well near Springfield, as shown in the log reproduced above with a thickness of about 36 feet, with conglomerate shale beds above for a distance of 25 or 30 feet. Thirty feet of sandstone lie near the base of the Pennsylvanian in a well near Macon at a depth of about 1,020 feet. In the Peoria region the base of the Pennsylvanian seems to be argillaceous material reported as either soapstone or shale, a sandstone 10 feet in thickness being reported in one out of seven water wells.[1] Farther west in Fulton County where the Pottsville is relatively thin the basal member is commonly sandstone or sandy shale. Toward the northern part of the district and farther north in District I sandstone is not a conspicuous constituent of the Pottsville. It seems probable, therefore, that the basal sandstone member is limited in distribution to the western border of the district and to the central and southern portions with possibly a greater thickness to the southeast than elsewhere.

Other sandstones are not uncommon in the Pottsville formation east of the Illinois and probably, as in District VII, they are variable in character and distribution. Drillings are too few, however, to test this probability or to justify reliable generalizations concerning the details of the rock succession over much of the area. A sandstone or sandy shale is noted in several wells in the upper 90 feet of the formation above the horizon of No. 1 coal as noted below.

A few coals lie within the Pottsville. Locally one bed, known as No. 1 (Rock Island, or Seville) coal, is of workable thickness. This is one of the two important coals of District III to the west and is of workable thickness beneath at least part of Fulton County in this district. The coal is mined at Seville and Ellisville along Spoon River, where it occurs about midway in the Pottsville section, 35 to 55 feet below No. 2 coal. At Seville it is 3 to 4½ feet thick and at Ellisville 3 to 5½ feet. The character and distribution of No. 1 coal in Fulton and Peoria counties will receive attention in greater detail in later sections of the report, and in the bulletin describing the coal resources of District III.

In the Peoria region what is possibly No. 1 coal lies 130 feet below No. 2 coal.[1] This coal was at one time mined in a shaft at Pottstown. Doctor Udden states in regard to it:

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[1] Udden, J. A., Geology and mineral resources of the Peoria quadrangle: U. S. Geol. Survey Bull. 506, p. 13, 1912.

> "It is in two benches, the lower one varying from 2 feet 2 inches to 3 feet in the Pottstown mine, and the upper measuring about 1 foot 3 inches. The two benches are separated by nearly 3 feet of shale. The average thickness of the coal and the included shale is 6 feet." [2]

At Peoria a thin, probably lenticular, coal lies at a still greater depth, about 80 to 104 feet, below No. 1 coal, or 20 feet above the base of the Pottsville formation at one locality. The Pottstown shafts and two water wells penetrated a thin coal about 40 feet above the horizon of No. 1 coal. Between this coal and No. 2 all exploration in the Peoria region shows considerable sandstone or sandy shale measuring from 70 to 80 feet in thickness.

In the Springfield region a 10-inch coal bed which lies about 142 feet above the base of the Pennsylvanian system and 140 feet below No. 2 coal, probably corresponds to the coal designated as No. 1 in the Peoria region. One boring, at least, indicates the presence of sandstone between No. 1 and No. 2 coals as in the Peoria region. A coal 12 to 16 inches thick is found in places in the Springfield region 35 to 40 feet below No. 2 coal.

Farther west a record of a diamond-drill boring at Blue Mound in Macon County reports several coals in the upper 130 feet of the Pottsville formation. The record of the boring at Blue Mound is reproduced herewith and is shown graphically on Plate II.

Record of a diamond-drill boring near Blue Mound, Macon County

Description of Strata	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Quaternary system—				
Pleistocene and Recent—				
Clay and sand	18	....	18	....
Sand	5	....	23	....
Clay and coarse gravel	3	....	26	....
Clay and gravel cemented	5	....	31	....
Clay, blue	22	....	53	....
Clay and gravel, cemented	3	....	56	....
Clay and sand	14	....	70	....
Clay and gravel, cemented	3	....	73	....
Boulders and gravel	2	....	75	....

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[1] Op. cit., p. 24.
[2] Op. cit., p. 25.

Record of a diamond-drill boring near Blue Mound—Continued

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian system—				
McLeansboro—				
Clay and shale, soft	23	....	98	....
Clay, soft	1	....	99	....
Shale, black	1	....	100	....
Coal, bone	....	6	100	6
Clay and shale, soft	10	6	111	....
Sand shale	3	....	114	....
Limestone	5	....	119	....
Sandstone	6	....	125	....
Clay shale	9	....	134	....
Clay shale	20	....	154	....
Clay shale	9	....	163	....
Clay shale with hard bands	22	....	185	....
Clay shale	6	....	191	....
Limestone (Carlinville?)	9	....	200	....
Clay shale, blue	1	....	201	....
Shale, black	4	....	205	....
Shale, dark blue	7	10	212	10
Bone	....	2	213	....
Fire clay	5	....	218	....
Limestone, bastard	7	....	225	....
Clay shale, blue	7	....	232	....
Limestone	1	....	233	....
Clay shale, light	6	....	239	....
Sand and limestone mixed with shale	5	....	244	....
Shale, sandy	11	....	255	....
Shale, sandy	5	....	260	....
Sand shale	8	....	268	....
Sand shale	7	....	275	....
Clay shale	16	....	291	....
Clay shale	10	....	301	....
Shale, black	1	....	302	....
Coal	....	6	302	6
Fire clay	1	6	304	....
Shale, clay	9	....	313	....
Clay shale with hard bands	17	....	330	....
Clay shale with hard bands	22	....	350	....
Clay shale, black	15	....	365	....
Clay shale, soft, will cave	12	....	377	....
"Soapstone," soft, red	5	....	382	....
"Soapstone," soft, red	3	....	385	....
Limestone	4	....	389	....
Clay shale	6	....	395	....
Clay shale	14	....	409	....

Record of a diamond-drill boring near Blue Mound—Continued

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Clay shale	6	....	415	....
Clay shale	4	....	419	....
Clay shale	9	....	428	....
Shale, dark blue	4	8	432	8
Coal	2	6	435	2
Fire Clay	1	6	436	8
Coal	....	8	437	4
Clay shale	13	8	451	....
Limestone	4	6	455	6
Clay shale	4	3	459	3
Carbondale—				
Coal (No. 6)	3	6	463	3
Shale	1	3	464	6
Limestone	4	6	469	....
Clay shale	10	....	479	....
Clay shale	7	....	486	....
Shale, black	3	....	389	....
Coal, clean parting (No. 5)	5	3	494	3
Fire clay	1	6	495	9
Clay shale	8	3	504	....
Clay shale	14	....	518	....
Clay shale	12	....	530	....
Shale, black	3	....	533	....
Coal	1	8	534	8
Shale, soft crumbly	3	4	538	....
Clay shale	5	....	543	....
Clay shale with hard bands	21	....	564	....
Clay shale with hard bands	18	....	582	....
Coal	3	6	585	6
Sand, clay, shale, mixed	12	6	598	....
Sand, clay, shale, mixed	2	....	600	....
Shale, black sandy	2	....	602	....
Coal	1	5	603	5
Clay and sandy shale mixed	5	7	608	....
Clay and sandy shale mixed	18	....	626	....
Clay shale	13	4	639	4
Coal (No. 2 coal)	1	2	640	6
Shale, mucky	1	6	642	....
Shale, mucky	1	....	643	....
Sandstone, hard	9	....	652	....
Shale, black	1	....	653	....
Coal	....	3	653	3
Shale, black	2	7	655	10
Coal mixed with sulphur	2	5	658	3

Record of a diamond-drill boring near Blue Mound—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Pottsville—				
Fire clay	1	6	659	9
Clay shale	4	3	664	....
Sandstone	4	....	668	....
Sandstone and sand shale mixed. Flowing salt water at 670 feet	15	....	683	....
Clay shale with hard bands	7	6	690	6
Shale, black	2	3	692	9
Coal	....	6	693	3
Clay shale	1	9	695	....
Clay shale	12	....	707	....
Clay shale	3	....	710	....
Sandstone	6	....	716	....
Shale, black	3	....	719	....
Coal	....	8	719	8
Clay shale	2	4	732	....
Clay shale	14	....	736	....
Shale, dark	2	....	738	....
Clay shale	2	....	740	....
Coal	....	2	740	2
Clay shale	1	10	742	....
Coal	....	6	742	6
Clay shale	3	6	746	....
Shale, dark	3	....	749	....
Coal and sulphur	....	8	749	8
Sandstone and sand shale	10	4	760	....
Clay shale, dark	2	....	762	....
Clay shale, dark	3	....	765	....
Shale, black	7	....	772	....
Coal	....	8	772	8
Clay shale	3	4	776	....
Sandstone (No. 1 coal?)	3	....	779	....
Sand shale	10	....	789	....
Coal	3	....	792	....
Clay shale	1	....	793	....
Sandstone	14	....	807	....
Sandstone	11	....	818	....
Sand shale and clay shale mixed	6	....	823	....
Clay shale	12	....	835	....
Sandstone	5	....	840	....
Sandstone, hard	10	....	850	....

On the basis of the correlation made in Plate II, a rough similarity is apparent in the sections at Blue Mound and Assumption, with an interval between coals No. 5 and No. 2 in one locality of 145 feet and in the other 155, and an interval betwen No. 1 and No. 2 of 115 feet at Blue Mound and 131 feet 7 inches at Assumption. These latter figures are not greatly different from those given for the interval between No. 1 and No. 2 coals in the Springfield and Peoria region.

In Sangamon, Macon, and Christian counties No. 2 coal seems to be everywhere in two benches.

A thin coal about 30 to 40 feet below No. 2 is apparently widespread as far northward as District I in Marshall and Bureau counties, and is possibly present at La Salle.

Limestone in the Pottsville is rather uncommon except in the western part of the district between No. 1 and No. 2 coals. In District III from Greene County to Rock Island County a limestone is nearly everywhere found between the two coals, commonly within a few feet of the upper coal, so that the underclay of this coal rests upon the limestone. This relationship, however, is more common to the south than to the north as the interval increases northward. In Fulton County, No. 1 coal is commonly overlain by a dark, shaly, somewhat impure limestone that varies in thickness from 5 to 20 feet, which may be separated from the coal by ½ to 3 feet of dark shale. Between the limestone and No. 2 coal is an interval of about 35 to 40 feet.

Except in the southeastern portion of the district the Pottsville sediments rest on a thick limestone of Mississippian age and the base can be definitely placed. In Macon and adjacent counties the Pennsylvanian system seems to be underlain by rocks belonging to the Chester group of the Mississippian system. These strata resemble the rocks of the Pottsville formation in being largely sandstone and sandy shales, so that it is not always possible to determine the position of contact of the two systems. The Chester, however, contains some limestone members, and as limestones are generally lacking in the Pottsville, it is the custom in the interpretation of drilling records from the central and southern part of the State arbitrarily to place the base of the Pottsville at the top of the first limestone after the drill has passed through all the main coal beds and has been working for some distance in a series composed mostly of sandstone. The top of the formation is difficult to identify where No. 2 coal is absent or not reported; in the Springfield region it averages about 240 feet below No. 6 coal; in the Peoria region in one shaft it is 140 feet below No. 6; in Macon County it is about 200 feet below No. 6. In general there is a decrease in interval northward through the State with the greatest difference taking place near the boundary between Districts VII and IV.

David White[1] has studied the fossil plants found in the formations and regards the Illinois beds as corresponding in age to beds of the same name in Pennsylvania.

CARBONDALE FORMATION

GENERAL DESCRIPTION

The Carbondale formation which is typically exposed near Carbondale, Jackson County, includes all the beds from the base of No. 2 coal to the top of No. 6 coal. Shale predominates in this formation, and only lenticular sandstones and minor amounts of limestone and coal are present. The Carbondale includes all of the productive coal beds in Illinois, except the Rock Island or Seville (No. 1), the Danville or Streator (No. 7) coals, three beds below No. 2 mined locally in Gallatin County, and two or three beds, high in the Pennsylvanian system, mined locally in the southeastern part of the State. Its total thickness varies from about 240 feet at Springfield and in the southeastern part of the district, to about 150 to 175 feet in the northern and northwestern parts.

The coal beds of commercial thickness in the region are No. 2, No. 5, and No. 6. The significance of these numbers has been adequately explained in preceding bulletins of this series, as has also the system of geographic names used by the State and the U. S. Geological Surveys for the same coals. By this system No. 2 coal is called the Murphysboro, La Salle, or Colchester coal; No. 5 coal is called the Springfield or Harrisburg coal; and No. 6 the Herrin, Belleville, or Grape Creek coal. Similarly, No. 1 of the Pottsville formation has been designated the Rock Island or Seville coal, and No. 7 of the McLeansboro formation, the Danville or Streator coal. It has been regarded as advantageous by the State Geological Survey to continue the use of numbers as synonymous with place names in this series of bulletins, calling attention, however, to the synonymous nomenclature.

The area of District IV includes most of that part of the State lying along the Illinois valley, wherein exposures of coal beds are found that furnished the basis for the Illinois valley section of the "Coal Measures" prepared by Worthen and presented in Volume III of the Geological Survey of Illinois (pages 3 to 6). In this region Worthen believed that he had identified ten beds of coal in a vertical thickness of about 600 feet. All were identified in the immediate vicinity of Illinois River except coal No. 4, which was seen only near Cuba in Fulton County. He numbered the coals from No. 1 upward, Nos. 1, 2, 5, and 6 corresponding to the numbers now being used for the respective beds. After investigations in the Fulton County region, Professor T. E. Savage states that the bed identified by Worthen as No. 4 is really No. 5, the original error being due to a decrease in the interval (undiscovered by Worthen) between No. 2 and No. 5 coals toward the west in Fulton County. Worthen's No. 3 coal has possibly not been identified with certainty by later investigators.

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[1] White David, Paleontological work in Illinois in 1908: Ill. State Geol. Survey Bull. 14, p. 193, 1910.

STRATA COMPRISING THE CARBONDALE FORMATION

The rock strata listed by Worthen[1] in the Carbondale portion of his section of the "Coal Measures" in central and northern Illinois are as follows:

	Thickness of stratum	Total thickness
	Feet	*Feet*
Coal (No. 6)	6	6
Fire clay passing into nodular limestone with fossils	3	9
Sandstone and sandy or argillaceous shale	35	44
Limestone, hard, bituminous	2	46
Shale, black	3	49
Coal (No. 5)	6	55
Fire clay, some places passing into argillaceous limestone	3	58
Shale and sandstone	20	78
Coal (No. 4)	3	81
Sandstone and sandy shale with dark blue and chocolate-colored bands at the base	80-100	181
Coal (No. 3)	3	184
Sandstone and sandy shales becoming argillaceous toward the base and inclosing nodules with fossil plants, insects, fishes, etc.	75	259
Coal (No. 2)	3	262

The stratigraphic units of the Carbondale in the Avon-Canton quadrangles as determined by T. E. Savage, are believed to be more accurate than those of Worthen, and are as follows:

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[1] Worthen, A. H., Geological Survey of Illinois, Vol. III, pp. 5 and 6, 1868.

		Thickness		Total thickness	
		Ft.	*In.*	*Ft.*	*In.*
16.	Coal (No. 6, or Herrin)	4-6	..	6	..
15.	Shale, gray to yellow	6-8	..	14	..
14.	Shale, sandy, and thin sandstone layers and sandstone	13	..	27	..
	———Unconformity———				
13.	Shale, gray (Canton shale)	17	..	44	..
12.	Shale, blue to gray, calcareous; "clod"	1	8	45	8
11.	Limestone, nodular	..	8	46	4
10.	Shale, black	2	..	48	4
9.	Coal (No. 5, or Springfield)	5	3	53	7
8.	Clay	2	6	56	1
7.	Limestone, nodular	1	..	57	1
6.	Shale, gray	12	2	69	3
5.	Sandstone and sandy shale	25	..	94	3
4.	Shale, gray	47	..	141	3
3.	Shale, black, with layer of nodular septaria boulders of limestone (Horizon of Worthen's No. 3 coal)	3-6	..	147	3
2.	Shale	9-14	..	161	3
1.	Coal (No. 2, or Avon)	2	6	163	9

The formation in the Fulton County region, especially near Cuba, is broken by an unconformity between No. 5 and No. 6 coals, whereby the interval between the two coals is lessened to apparent contact in at last one place, with various distances separating the coal up to the usual interval of about 65 feet as found near Canton. This varying interval between the coals was apparently not noted by Worthen, so that No. 5 was erroneously called No. 4 where it was the greater distance below No. 6, and No. 5 where it was the lesser.

In the Peoria County region the Carbondale section apparently begins with the No. 2 (Blue Fly) coal bed which was worked at Pottstown and Orchard. This coal lies 190 to 200 feet below the top of the formation or 140 feet below No. 5 coal, which is about 30 feet more than the interval in the Fulton County region. In both Fulton and Peoria counties No. 2 coal is covered by "soapstone" followed by black shale probably containing "niggerheads" or boulders of septaria limestone. The correlation of the other members of the section is impossible with the data at hand. As in the Fulton County region, however, the lower part of the section is shale and the upper part up to the underclay of No. 5 coal is largely sandstone.

The succession between No. 5 and No. 6 coals in the Peoria region is very similar to that in the Fulton County area. The unconformity mentioned above in the description of the Fulton County section is present in the Peoria area and in both regions the material resting upon the eroded surface is sandstone or sandy shale. Udden states[1] as follows:

> **"The surface separating this shale from the overlying sandstone is not always a straight line or even plane. There are many broad low combs in the lower surface of the sandstone which extend down into the shale. On close inspection of the bared bottom of overhanging parts of the sandstone, especially in places where it has a coarse texture, these combs are seen to have the forms of molds made in small channels, which were cut by rills into the mud bottom of the underlying shale. The largest of these channels noted on the old mud flats is 3 feet wide and about 9 inches deep, evidently a cut such as might have been made by the receding tide. To what extent the differences already mentioned in the thickness of the shale may be due to more extensive erosion at this level it is not possible to say, but it appears probable that some erosion had taken place."**

In the Springfield region the average thickness of the Carbondale formation is about 243 feet, or about 50 feet more than in the Peoria region. No. 2 coal, at the base, is commonly in two beds, each ranging from 7 to 24 inches in thickness. They are separated by a few feet of dark shale. Above the coal there is about 10 to 15 feet of shale or shaly sandstone, upon which lies 25 to 35 feet of micaceous and somewhat argillaceous sandstone interbedded with layers of shale. From the top of the sandstone to the base of the Springfield (No. 5) coal the strata consist of a series of shale beds varying in color from gray to blue or black. At some places they appear to be slightly sandy; at others they contain thin beds of coal. In the Springfield boring a thin coal bed was encountered 56 feet above the base of the formation and a similar coal was found at nearly the same horizon in a drilling near Riverton. About 30 feet above this bed another thin coal was found in each hole, and still another 140 to 150 feet above the base of the formation.

The interval between No. 5 and No. 6 coals is much the same throughout the Springfield region. Above the No. 5 coal is commonly black "slate," with niggerheads and with irregular gray markings resembling fucoid impressions traversing the beds and appearing on the edges of the blocks as light-gray laminae intercalated between darker material. Locally in the Springfield region a layer of "clod" or calcareous shale containing much pyrite lies between the coal and the black shale. In Peoria and Fulton counties "clod" is found locally at the position of the limestone "cap rock" above the black slate. Overlying the "cap rock" commonly is a shale of varying thickness overlain in turn by sandstone which latter member is particularly conspicuous in the Peoria region, where in places it is exposed to a thickness of 55 to 60 feet. Between the sandstone and underlying strata is probably an erosional unconformity. A similar sandstone lies above No. 5 coal in places in the La Salle region, and west of the La Salle anticline possibly in places extends below the horizon of No. 5 within about 100 feet or less of No. 2 coal. In District I this sandstone has been designated the Vermilionville sandstone. In District IV the sandstone changes vertically somewhat abruptly into shale and fire clay, the latter forming the underclay of No. 6 coal. There is commonly 7 to 10 feet of this shale between the coal and the sandstone.

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[1] Udden, J. A., Geology and mineral resources of the Peoria quadrangle: U. S. Geological Survey Bull. 506, p. 31, 1912.

The thickness of the Carbondale formation apparently is somewhat more in Sangamon County than it is to either the east or the west. Its thickness of 240 feet near Springfield has already been compared with a thickness of 190 to 200 feet at Peoria. In Macon County there is about 190 feet of Carbondale sediments present, and at Bloomington between 132 and possibly 175 feet. No. 6 coal is apparently absent over much of McLean County so that the exact position of the top of the Carbondale is undeterminable.

No. 6 coal is not widespread in this district. In the Springfield area it is found as a thin coal 14 inches or less in thickness and at an average interval of 50 feet above No. 5 coal. The coal increases in thickness southward rather rapidly, so that at Auburn and Chatham it is 5 to 8 feet thick. In the Peoria and Fulton County region, also, it is 4 to 6 feet thick. Very locally at Springfield the coal thickens to 5 or 6 feet as in the shaft at Mechanicsburg. To the east and north the coal entirely plays out so that the exact position of the top of the Carbondale formation is indeterminable and No. 7 coal is the next bed of workable thickness above No. 5 coal. This relationship persists northward over much if not all of District I. The absence of No. 6 coal is thought to be due to an interval of erosion or nondeposition near the end of Carbondale time. The gap may be due to the same causes which produced the erosion unconformity already described between No. 5 and No. 6 coals in the Fulton and Peoria County region, sandstone deposition continuing for longer period in the central portion of the State than it did to the west. This seems to be in harmony with movements which apparently took place along the La Salle anticline at about the end of the Carbondale period, one effect of which would doubtless have been to make the adjacent portion of the coal basin unfavorably located for peat deposition. There is considerable State-wide evidence for believing that an emergence

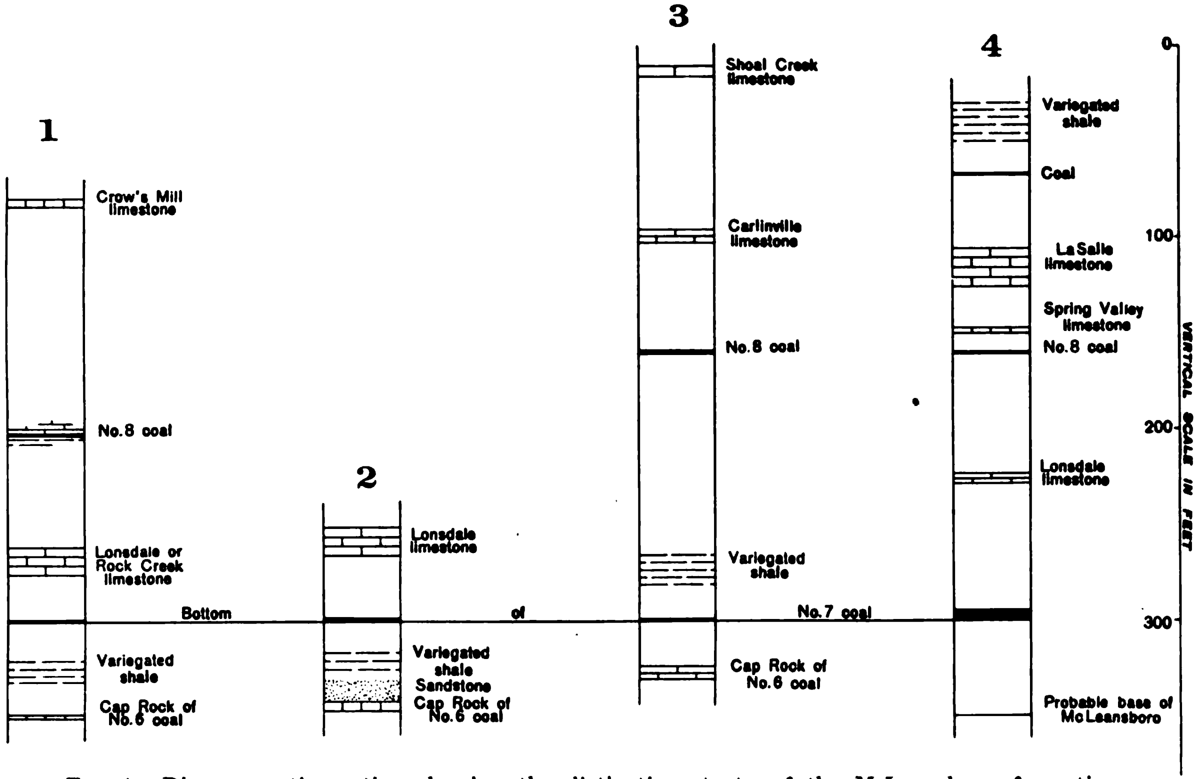

FIG 4.—Diagrammatic section showing the distinctive strata of the McLeansboro formation:
1. In District IV as a whole
2. In the Peoria region
3. In Macon County and District VII
4. In the northern part of District IV and in District I

of the sea bottom accompanied by erosion took place near the end of Carbondale time, but the exact position of the line of unconformity in the various parts of the State varies across the horizon of coal No. 6, in some places being above and in other places below or at the horizon of the coal. In southeastern Illinois and western Kentucky the line of this unconformity is thought to be marked by the base of the Anvil Rock sandstone, which lies near the base of the McLeansboro formation.

MCLEANSBORO FORMATION

GENERAL DESCRIPTION

The McLeansboro formation includes all of the "Coal Measures" strata above No. 6 coal. It takes its name from McLeansboro, Hamilton County, Illinois, where borings have penetrated it to a depth of one thousand feet. It underlies the entire region north and east of the line of outcrop of No. 6 coal, and in most of the district is covered by a variable thickness of glacial drift.

The formation consists of shale and minor amounts of sandstone, limestone, and coal. Although some of the coals above No. 6 are persistent in distribution, only No. 7 coal is anywhere sufficiently thick in this area to be of commercial value. In its barrenness of productive coals and in general age, the McLeansboro is similar to the Conemaugh formation of Pennsylvania.

DISTINCTIVE STRATA

The well differentiated distinctive strata of the McLeansboro formation in this region as a whole may be enumerated as follows (Fig. 4):

6. **Crows Mill limestone; about 275 feet above No. 6 coal.**
5. **No. 8 coal, with limestone above and greenish-gray shale below; about 150 feet above No. 6 coal.**
4. **Lonsdale or Rock Creek limestone; about 75 feet above No. 6 coal and 30 to 40 feet above No. 7 coal.**
3. **No. 7 coal; averages about 50 feet above No. 6 coal.**
2. **Variegated shale between cap rock of No. 6 coal and No. 7.**
1. **A hard limestone cap rock overlying or a few feet above No. 6 coal.**

In the Peoria region the following units may be observed (Fig. 4):

5. **Lonsdale limestone; about 15 feet thick, 30 to 40 feet above No. 7 coal.**
4. **No. 7 coal; about 18 inches thick, 20 to 50 feet above No. 6 coal.**
3. **Variegated shale 8 feet and less in thickness; 18 to 40 feet above No. 6 coal.**
2. **Sandstone; 10 to 25 feet thick, 8 to 17 feet above No. 6 coal.**
1. **Limestone; about 5 feet thick, 2 to 4 feet above No. 6 coal.**

In Macon County a section similar to that noted in District VII[1] to the south is recorded at Blue Mound, including the following distinctive horizons (Fig. 4):

6. Shoal Creek limestone; about 100 feet above the Carlinville limestone, and 300 feet above No. 6 coal.
5. Carlinville limestone; about 230 feet above No. 6 coal.
4. No. 8 coal; 150 to 180 feet above No. 6 coal.
3. Variegated shale; about 60 feet above No. 6 coal.
2. No. 7 coal.
1. Cap rock of No. 6 coal.

The section in the northern part of this district seems to be much like the section in District I where the following distinctive horizons may be recognized (Fig. 4):

7. Variegated shales; about 250 feet above No. 7 coal.
6. Coal; about 232 feet above No. 7 coal.
5. Limestone, La Salle; about 180 feet above No. 7 coal.
4. Limestone, Spring Valley; about 150 feet above No. 7 coal.
3. No. 8 coal; about 140 feet above No. 7 coal.
2. Lonsdale limestone; about 75 feet above No. 7 coal.
1. No. 7 coal, of commercial thickness; possibly about 50 feet above the base of the McLeansboro formation, No. 6 coal not being present.

The identification of the various strata of the McLeansboro formation as well as those of the earlier formations is accomplished by comparison of sections in adjacent drill holes and by a few exposures in the upper part of the section in the central part of the district. Similarity of interval between successive distinctive strata in various places is practically the only criterion of identification, as fossil studies have not as yet yielded index fossils for the various positions in "Coal Measures," as they may do if collections were systematically made and studied.

Identifications of strata on the basis of lithologic similarity and similarity in stratigraphic interval have been rather satisfactory in the southern part of the State where drilling is closely spaced, and the various formations are widespread at characteristic intervals. Comparison of sections in various parts of northern Illinois seems to indicate that the same method is applicable here likewise, but in all parts of the coal basin there is need for paleontologic verification of such identifications by the aid of fossil collections.

Because of the irregularity in the distribution of drilling, and geologic and other exploratory work, and because of the consequent lack of knowledge of conditions in Menard, Logan, and DeWitt counties, the southern part of the district, comprising Sangamon and Macon counties, is isolated from the northern and western part of the district including Schuyler, Fulton, Peoria, Tazewell, McLean, Woodford, and Livingston counties and the area included in District I. The section for Peoria and Fulton counties continues northward and in Marshall County merges into the section which is characteristic of District I as displayed in the La Salle region west of the La Salle anticline. At Sparland, No. 6 coal pinches out and is not present northward. No. 7 coal persists from the Peoria region into the La Salle region becoming thicker in that direction, and the Lonsdale limestone can be traced almost continuously from one district to the other. At Toluca, No. 6 coal is absent, but a limestone, possibly the cap rock of No. 6, below which is a black "slate," has been encountered in one drill hole, indicating a transition from the conditions in one area to those in the other. The following record of a drilling at Toluca illustrates the relationships.

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[1] Kay, Fred H., Coal Resources of District VII: Ill. Min. Investigations Bull. 11, p. 23, 1915.

Record of boring near Toluca, in the S. W. ¼ N. E. ¼ sec. 5, T. 29 N., R. 1 E.

Description of Strata	Thickness		Depth	
	Ft.	*In.*	*Ft.*	*In.*
Soil, black	1	....	1	....
Clay, brown	5	....	6	....
Clay, gray	6	....	12	....
Sand clay, brown	5	....	17	....
Sand (water)	8	....	25	....
Clay, gray and red	43	....	68	....
Limestone	3	....	71	....
Soapstone, light red	20	....	91	....
"Soapstone," pink	8	....	99	....
Limestone	3	....	102	....
Silt, black	3	....	105	....
Soapstone, light gray	8	....	113	....
"Soapstone," red	4	....	117	....
Limestone	7	6	124	6
"Soapstone," gray	5	6	130	....
Limestone	2	....	132	....
"Soapstone," dark	3	....	135	....
"Soapstone," gray	2	....	137	....
Clay, red	11	....	148	....
Limestone	7	....	155	....
Clay, red	1	....	156	..
"Soapstone," red	4	....	160	....

Record of boring near Toluca—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Clay, red	7	....	167	....
"Soapstone," gray	3	....	170	....
Clay, red	2	....	172	....
"Soapstone," gray	11	....	183	....
"Slate," black	2	....	185	....
"Soapstone," gray	1	....	186	....
Limestone	13	....	199	....
Clay, red	9	....	208	....
"Soapstone," dark	8	....	216	....
Limestone	5	....	221	....
"Soapstone," gray	14	....	235	....
Sandstone	14	....	249	....
"Soapstone," gray	14	....	263	....
"Soapstone," sandy	9	....	272	....
"Soapstone," gray	7	....	279	....
"Slate," black	3	....	282	....
"Soapstone," gray	6	....	288	....
Coal ("1st vein" or No. 7)	4	3	292	3
Fire clay	8	9	301	....
"Soapstone," gray	16	6	317	6
Limestone	1	6	319	....
"Slate," black	4	....	323	....
"Soapstone," gray	5	....	328	....
"Slate," black	14	....	342	....
Coal ("2d vein" or No. 5)	2	....	344	....
Fire clay	7	....	349	....
"Soapstone," gray	17	....	366	....
Fire clay	4	....	370	....
"Soapstone"	15	....	385	....
Sand shale	10	....	395	....
Sand shale	9	....	404	....
"Soapstone," sandy	90	....	494	....
"Soapstone," gray	5	....	499	....
Coal ("3d vein" or No. 2)	2	6	501	6
Fire clay	3	6	505	....

The succession of the Longwall District, which as has been stated, can be traced into the Peoria area along the Illinois valley, persists southward in the eastern part of District IV along the line of the Illinois Central Railroad at least at far as Bloomington. Accordingly, as in the Longwall District, the coals in the northern part of District IV are commonly known as "first," "second," and "third vein" coals, and, as in the La Salle region, the "first vein" is No. 7 of the Illinois section, the "second vein," No. 5, and the "third vein" is No. 2. No. 6 coal, as has been stated, is absent in this part of the State.

Between Bloomington and the south boundary of the district, the section changes with the thinning of No. 7 coal, and with the intercalation of No. 6 coal and its cap-rock limestone between coals No. 7 and No. 5. The stages of this transition have not been determined, as the details of the section between Bloomington and Decatur are not well known, very little drilling having been done in that part of the district. Not improbably it is very similar to the change that takes place in the section along the Illinois valley between Peoria and the Longwall District.

In the following paragraphs each of the distinctive strata of District IV in the McLeansboro formation as previously listed, will be described in some detail.

1. *Limestone above No. 6 coal.*—No. 6 coal is of workable thickness in this district only in Fulton, Schuyler, and Peoria counties. In most of the area it is absent. Where this coal is present it has a persistent limestone cap rock which possibly has a wider distribution than the coal itself. In the Peoria region this cap rock ranges in thickness from 3 inches to 4 feet and averages a little more than 2 feet. In places it is absent from the section. A similar limestone is reported over the No. 6 coal in Springfield region. A black shale commonly separates the coal from the limestone in all regions, but in places in the Peoria region this shale and even the limestone and some of the coal is replaced by a variable sandy deposit known among the miners as "white top." In the northern part of the State a similar material is found associated with No. 5 coal, particularly at La Salle and Cherry.

2. *Variegated shale below No. 7 coal.*—Savage reports a persistent bed of variegated calcareous shale, red, blue, greenish, chocolate-colored, and mottled, occupying part of the section between the cap rock of No. 6 coal and No. 7 coal in the Springfield region. Reddish shales at about the same horizon have been noted by Savage in the Canton region and by Udden in the Peoria region. It is noteworthy that similar variegated shales are remarkably persistent in District IV at a higher horizon, namely, about 50 feet above No. 6 coal and as a rule a short distance above rather than below the horizon of No. 7 coal. Reddish shales do not occur in the northern part of the district or in District I nearer than about 40 feet above No. 7 coal, but above that level are rather common.

3. *No. 7 coal.*—No. 7 coal is one of the three persistent coal beds of this district. It is thin to the south and southwest, averaging only

2½ inches in thickness in the Springfield quadrangle,[1] and in places represented only by a thin bed of black shale. In the Peoria quadrangle it averages 1 foot 5 inches in thickness, and Savage reports an average thickness of 12 to 18 inches in the Avon and Canton quadrangles. North from Bloomington and Chillicothe the coal becomes of workable thickness, and it has been mined at various places in the northern part of the State, most notably at Streator. This coal will be described in greater detail on later pages.

4. *Lonsdale limestone.*—The Lonsdale limestone is one of the widely distributed limestones in the "Coal Measures" of northern Illinois. It has not been identified south of Sangamon County, but it occupies a stratigraphic position similar to that of certain limestones found in Randolph and Perry counties a short distance above the coal identified as No. 7. The limestone has been traced from Fulton County northward to Bureau County, is probably represented by one of the several limestones in the upper part of the Pennsylvanian system in the La Salle region, and has been tentatively correlated with the limestone outcrop along Vermilion River between Streator and Pontiac. It is believed to be the same as the Rock Creek limestone of the Springfield region.[2]

This limestone was first described by Worthen[3] from the old Lonsdale quarries in the Peoria region. Udden[4] describes it as consisting of a lower 5 feet of firmly cemented, largely organic limestone in beds varying in thickness from 6 inches to 18 inches, and in character from typical crinoïdal limestone to calcareous mud-lump breccia; and an upper bed 15 feet thick of slightly argillaceous more flaggy rock, in which concretionary structures can nearly always be detected.

In the Peoria region this limestone lies 40 to 50 feet above No. 7 coal; in the Canton region about 60 feet above the coal; in the Springfield region (supposing it to be the same as the Rock Creek limestone), about 45 feet; in the Streator region about 70 feet; and at Bloomington possibly about 70 feet. The Lonsdale limestone has not been definitely identified in the southeast part of the district nor generally in the southern part of the State.

5. *No. 8 coal.*—No. 8 coal, although too thin to be of commercial importance, has a persistence comparable to that of any coal beds of the State. It can be traced throughout Districts VII, VI, and probably V, practically to Ohio River. It is commonly between 12 to 18 inches thick, but locally increases to 30 inches. Locally it is absent. It is gen-

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[1] U. S. Geological Survey Folio 188, p. 5.
[2] U. S. Geological Survey Folio 188, p. 6.
[3] Worthen, A. H., Geological Survey of Illinois Vol. 5, p. 238, 1873.
[4] Udden, J. A., Geology and mineral resources of the Peoria quadrangle: U. S. Geological Survey Bull. 506, pp. 39-40, 1912.

erally overlain by black shale. This thin coal lies approximately halfway between No. 6 coal and the Carlinville limestone. The various intervals between this coal and No. 7 in District IV may be observed by inspection of the following table:

TABLE 1.—*Interval between No 8 and No. 7 coals in District IV compared with the range of interval in District VII*

Locality	Interval *Feet*
Springfield	77
Niantic	100
Blue Mound	140
Decatur	130+
Lovington	150
Assumption	130
Divernon	120
La Salle	147?
Saybrook	169
District VII	150-180

6. *Carlinville limestone.*—The Carlinville limestone is one of the most widely distributed beds in the "Coal Measures" of Illinois. It has been traced from the Indiana State line in Gallatin County northeast to Carlinville, Macoupin County, and is probably the same as the Crows Mill limestone of the Springfield region and the La Salle limestone of the La Salle region.

In the type localities this limestone is, according to Udden[1], "generally bluish gray, compact, close-textured, and very hard, breaking into irregular, splintery pieces. On weathering it assumes a rusty color. It averages about 7 feet in thickness. There are two features that are characteristic of this limestone, one a blotchy appearance and the other its tendency to weather into seams two and one-half or three inches in thickness."

The various intervals between this limestone and No. 6 and No. 7 coal, so far as either or both are present, is shown in the accompanying table.

TABLE 2.—*Intervals between the Carlinville limestone and No. 6 and No. 7 coals*

	Interval	
Locality	To No. 6 coal *Feet*	To No. 7 coal *Feet*
Macoupin County	200-220	200±
Springfield (Crows Mill limestone)	210-215	160
Divernon	215±	160
Niantic	190	175
Blue Mound	225	190
Maroa	225	200
Decatur	190	180

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[1] Udden, J. A., Shoal Creek limestone; Illinois State Geological Survey Bull. 8, p. 119, 1908.

Locality	Interval To No. 6 coal *Feet*	 To No. 7 coal *Feet*
Lovington (Shoal Creek limestone?)	300	270
Assumption	...	220
Toluca	190±	170
Saybrook	290?	180
District VII		
(Central and southern parts)	275-325	...
(Northern part)	200-275	...

As in the case of the interval between the No. 7 coal and the Lonsdale limestone and No. 8 coal, there is a general decrease in interval in the Sangamon County region in passing from adjacent regions to the east and southeast, and possibly to the northwest.

The equivalency of the Carlinville and La Salle limestones was postulated as probable by Worthen,[1] who says:

> "I have been inclined to regard this limestone as the equivalent of that at Carlinville, which it resembles, both in its lithologic character and in the specific character of its embedded fossils. * * * It is rather more argillaceous here than in Macoupin County, but otherwise it bears a close resemblance to that rock, and its position is about where that limestone, if present here, should be found."

While investigations by the present Survey have yielded no definite evidence from fossil collections of the correlation of the two limestones, they indicate the probable correctness of Worthen's determination; at least, they do not throw any doubt upon it.

7. *Higher distinctive horizons.*—Erosion has cut off the Pennsylvanian strata in the district shortly above the horizon of the Carlinville limestone. Possibly in Macon, Dewitt, and southeastern McLean counties, strata as high as No. 9 coal and the Shoal Creek limestone are preserved where the rock surface is highest. Such is not known to be the case, however. Both of these members are possibly present very locally in the La Salle region.

The New Haven limestone, which is fairly widespread in southern Illinois within the area surrounded by its outcrop, lies about 200 to 250 feet above the Carlinville limestone, and apparently outcrops near the north boundary of District VII between Assumption and Lovington on the south and southeast, and Decatur on the north.

According to the old classification of Worthen whereby the Pennsylvanian strata in Illinois were separated into lower and upper "Coal Measures" at the horizon of No. 9 coal, the upper measures are lacking in this district except possibly for a narrow belt extending northward along the east boundary

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[1] Geological Survey of Illinois, Vol. 7, p. 48.

CHEMICAL VALUE OF COALS IN DISTRICT IV

A detailed report on the chemical character of Illinois coals has been published as Bulletin 3[1] of this series, so that a discussion of the quality of the coals in this district is not necessary. However, for convenience, tables 3, 4 and 5 are here given. Tables 3 and 4 relate only to the coals in the counties treated in this report. Table 5, which shows the average district analyses of coals, is presented for ease of general comparison of the District IV coals with those of the other districts. In Plate IV the same material as is given in table 5 is presented in graphic form.

A very brief statement of the meaning of each of the several columns, which give the results of analyses in tables 3, 4 and 5, will doubtless be of service in rendering these results more intelligible, and therefore of greater usefulness to the average reader unfamiliar with the technology of coal.

The "Proximate analysis" columns group the compounds which either make up the coal or are derived from it, into water, ash, volatile matter, and fixed carbon, the last two comprising the combustible matter. A recalculation of the results of each analysis is given on the second line in most cases, showing percentage of the various constituents on the hypothetical basis of no moisture in the coal.

The moisture content of coal though unavoidable is detrimental. Not only does the water displace its own weight of combustible matter, but in addition it absorbs heat during burning, 100 B.t.u's per pound being a common figure for ordinary bituminous coal of average moisture content. Obviously, other factors being equal, a coal of the lowest possible moisture content should be purchased.

The ash in coal (chiefly compounds of silica, alumina, lime, and iron, together with smaller quantities of magnesia, titanium, and alkali compounds) is another harmful constituent. Not only does it displace its own weight of heat-forming compounds, and decrease the efficiency of combustion just as does the moisture content, but in addition any increase in ash percentage means a corresponding increase in the cost of handling the coal, by making both freight costs and costs of disposition of the refuse greater. Furthermore, certain types of ash contain such high percentages of iron and alumina that they fuse easily and cause clinkering trouble in furnaces.

The "volatile matter" and "fixed carbon" columns give the relative amounts of gaseous and solid combustible matter. They are, of course, the heat-producing constituents. For domestic use a low-volatile coal is to be preferred because the ordinary domestic stoves and furnaces are capable of utilizing only a small proportion of the volatile matter. However, modern steam-generating appliances such as are used industrially are so constructed as to take care of the gases satisfactorily and either low- or high-volatile coal can be used with equal efficiency.

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[1] Parr, S. W., a chemical study of Illinois coals: Ill. Coal Mining Investigations Bull. 3, 1916. This bulletin is out of print, but the analyses it contains have been reprinted in State Geological Survey Bulletin 29, in a paper by S. W. Parr on "The Purchase and Sale of Illinois Coal under Specifications."

Sulphur is present generally in the form of pyrite (iron sulphide.) It is especially deleterious in the manufacture of coke and gas, and if associated with an ash of high lime and iron content it may help to cause clinkering. Otherwise it is not particularly harmful, for as a rule it displaces a negligible amount of combustible material, and has some virtue in that it does not absorb heat as do water and ash, but will even produce about a third as much heat as does carbon.

The "B.t.u." column gives the calorific (heat) values of the coals in British thermal units per pound of coal. These values indicate the proportional heating power of the coals and are therefore extremely important as a means of comparison. In their calculation, account is taken of the ash and moisture present, as well as the combustible matter.

"Unit coal," on the contrary, takes account only of the pure coal substance, free from ash, moisture, sulphur, or other impurities. Since the "pure coal" is essentially the same for any single mine from year to year, the "unit-coal" figure will remain practically unchanged; the "B.t.u." figure, however, will vary in proportion to the variations from place to place in the mine in the amount of ash, sulphur, and moisture present, and therefore for the average practical user, up-to-date B.t.u. values will afford a more satisfactory means of comparison of the coals than will the "unit-coal" values, useful though they may be for certain purposes.

TABLE 3—*Analyses of mine samples from District IV*

Not exactly indicative of commercial output

Lab. No. (a	File No. (b	Date of analysis (c	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5229	1602	7/12	Christian........	1	11.27	38.68	40.55	9.50	2.07	.33	11445	....
	C21				Dry	43.59	45.70	10.71	2.33	.37	12898	14666
5230	1602	7/12	Christian........	1	11.52	38.78	41.01	8.69	2.42	.97	11648	....
	C21				Dry	43.83	46.35	9.82	2.73	1.10	13163	14707
5231	1602	7/12	Christian........	1	11.13	39.21	41.26	8.40	2.56	.61	11715	....
	C21				Dry	44.12	46.43	9.45	2.88	.69	13183	14779
5205	1602	7/12	Christian........	2	12.07	39.36	41.91	6.66	3.74	.07	11776	....
	C21				Dry	44.77	47.66	7.57	4.26	.09	13393	14730
5206	1602	7/12	Christian........	2	12.53	38.00	40.62	8.25	3.67	.31	11389	....
	C21				Dry	44.12	46.44	9.44	4.22	.35	13020	14641
5207	1602	7/12	Christian........	2	14.30	39.54	40.30	5.86	2.00	.24	11609	....
	C21				Dry	46.14	47.02	6.84	2.33	.28	13544	14702
1869	1602	10/08	Christian........	2	11.54	36.65	42.89	8.92	3.87	....	11631	....
					Dry	41.42	48.50	10.08	4.38	....	13148	14912
12469	0328	4/21	Fulton...........	1	11.38	38.66	39.51	10.45	4.52	.87	11436	....
					Dry	43.62	44.58	11.80	5.10	.98	12905	14979
12470	0328	4/21	Fulton...........	1	11.42	38.17	40.07	10.34	4.76	.45	11409	....
					Dry	43.09	45.24	11.67	5.37	.51	12880	14934
12471	0328	4/21	Fulton...........	1	10.84	38.42	40.91	9.83	5.61	.54	11554	....
					Dry	43.09	45.88	11.03	6.29	.61	12959	14939

TABLE 3—*Analyses of mine samples from District IV*—Continued

Lab. No. (a	File No. (b	Date of analysis (c	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
1858	0328	9/08	Fulton..........	1	17.21	37.49	38.69	6.61	3.90	....	11147	....
					Dry	45.28	46.73	7.99	4.71	....	13464	14904
2753	1422	......	Fulton..........	2	14.87	35.80	43.88	5.45	....	....	11641	....
					Dry	42.06	51.54	6.40	3.69	....	13674	14083
12442	0102	4/21	Fulton..........	5	15.43	33.62	39.47	11.48	2.50	1.41	10389	....
					Dry	39.76	46.67	13.57	2.66	1.67	12285	14473
12443	0103	4/21c	Fulton..........	5	14.43	34.60	39.09	11.88	2.82	2.45	10320	....
					Dry	40.43	45.69	13.88	3.29	2.86	12061	14297
12444	0103	4/21	Fulton..........	5	15.00	33.10	37.31	14.59	3.38	2.86	9834	....
					Dry	38.94	43.89	17.17	3.98	3.36	11569	14300
12445	0103	4/21	Fulton..........	5	14.69	34.07	40.18	11.06	2.83	1.75	10383	....
					Dry	39.94	47.09	12.97	3.32	2.05	12172	14266
12446	0103	4/21	Fulton..........	5	14.52	34.46	37.64	13.38	2.91	2.74	10045	....
					Dry	40.31	44.04	15.65	3.40	3.21	11752	14261
12447	0103	4/21	Fulton..........	5	14.75	33.18	38.89	13.18	3.70	1.54	9869	....
					Dry	38.92	45.62	15.46	4.34	1.81	11577	14298
12448	0103	4/21	Fulton..........	5	14.28	34.93	38.76	12.03	2.56	1.98	10329	....
					Dry	40.75	45.22	14.03	2.99	2.31	12061	14316
12472	0104	4/21	Fulton..........	5	15.32	35.12	38.05	11.51	2.59	1.41	10482	....
					Dry	41.48	44.93	13.59	3.06	1.66	12379	14617
12473	0104	4/21	Fulton..........	5	15.09	13.37	39.41	10.13	2.68	1.79	10741	....
					Dry	41.66	46.41	11.93	3.16	1.66	12650	1463[illegible]
12474	0104	4/21	Fulton..........	5	15.56	35.68	38.92	9.84	2.43	1.33	10753	....
					Dry	42.26	46.09	11.65	2.88	1.58	12735	14668
12475	0104	4/21	Fulton..........	5	14.56	35.37	38.98	11.09	2.72	1.38	10581	....
					Dry	41.40	45.62	12.98	3.19	1.62	12384	14512
12476	0104	4/21	Fulton..........	5	15.39	33.82	38.77	12.02	3.40	1.67	10338	....
					Dry	39.97	45.82	14.21	4.02	1.97	12219	14565
12477	0104	4/21	Fulton..........	5	15.66	34.65	37.56	12.13	2.93	1.88	10242	....
					Dry	41.08	44.54	14.38	3.47	2.23	12144	14583
12439	0111	4/21	Fulton..........	5	13.37	36.03	39.03	11.57	3.06	1.46	10787	....
					Dry	41.59	45.06	13.35	3.52	1.69	12452	14670
12440	0111	4/21	Fulton..........	5	14 44	34.71	38.58	12.27	2.17	1.80	10578	....
					Dry	40.57	45.09	14.34	2.54	2.10	12364	14683
12441	0111	4/21	Fulton..........	5	14.96	33.65	39.96	11.43	4.32	1.11	10502	....
					Dry	39.57	46.99	13.44	5.08	1.30	12352	14616

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a) The analyses that have "US" laboratory numbers were made by either the U. S. Bureau of Mines or the U. S. Geological Survey, as indicated in later footnotes which make reference to their place of publication.

b) Analyses having the same file number are for a single mine. It should be remembered that as much dependence can not be placed on a single analysis from a given mine as may be placed on a group from one mine.

Analyses having "C" file numbers are republished from State Geological Survey Bulletin 29, and Illinois Mining Investigations Bulletin 3, and belong to a series made by J. M. Lindgren under the general supervision of Professor S. W. Parr of the University of Illinois, for those bulletins.

c) The Fulton County analyses that have April, 1921, as the date of analysis, were made on samples recently collected by or under the supervision of H. E. Culver of the Survey staff.

TABLE 3 *Analyses of mine samples from District IV*—Continued

Lab No.	File No.	Date of analysis	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
[illegible]	[illegible]	8/12	Fulton	5	16 36 Dry	33 91 40 54	38.19 45 66	11.54 13.80	2 93 3.50	1.27 1.51	10186 12179	 14431
[illegible]	[illegible]	8/12	Fulton	5	16.33 Dry	35.50 42.42	37 01 44 23	11.16 13.35	2 89 3.45	1.84 2.20	10220 12213	 14389
[illegible]	[illegible]	8/12	Fulton	5	15.85 Dry	36.12 42.92	38.12 45.30	9 91 11.78	3.36 4.00	1.47 1 75	10494 12471	 14386
[illegible]	[illegible]	8/12	Fulton	5	17 13 Dry	36.23 43.72	34.44 41.55	12.20 14.73	3.03 3.66	1 79 2.16	9846 11882	 14252
[illegible]	[illegible]	8/12	Fulton	5	16.59 Dry	35.98 43.14	37.20 44.61	10.23 12.25	4.07 4.88	1 77 2.12	10271 12314	 14354
[illegible]	[illegible]	8/12	Fulton	5	15 41 Dry	35.67 42.16	39.04 46.15	9.88 11.69	3.31 3.92	.52 .61	10579 12505	 14443
[illegible]	[illegible]	4/21	Fulton	5	14 57 Dry	35 24 41.25	39.58 46.33	10.61 12.42	2.89 3.38	1.00 1.17	10562 12363	 14391
[illegible]	[illegible]	4/21	Fulton	5	16 16 Dry	35 65 42.52	37.89 45.19	10.30 12.29	2.50 2.98	1.56 1.86	10422 12431	 14434
[illegible]	[illegible]	4/21	Fulton	5	13 35 Dry	37 84 43 67	39.86 46.00	8.95 10.33	2.22 2.56	1.77 2.04	10843 12514	 14150
[illegible]	[illegible]	4/21	Fulton	5	15 86 Dry	35 20 41 84	37.32 44.35	11.62 13.81	3.49 4.15	1.31 1.56	10198 12120	 14380
[illegible]	[illegible]	4/21	Fulton	5	14 34 Dry	35 09 40 96	36.72 42.87	13.85 16.17	3.84 4.48	2.47 2.89	9944 11609	 14217
[illegible]	[illegible]	4/21	Fulton	5	14 62 Dry	36 18 42.38	39.21 45.92	9.99 11.70	2.43 2.85	1.49 1.74	10719 12555	 14465
[illegible]	[illegible]	8/12	Fulton	5	13 66 Dry	38 46 44 54	37 06 42.92	10.82 12.54	3.64 4.22	1.26 1.46	10689 12379	 14462
[illegible]	[illegible]	8/12	Fulton	5	14 53 Dry	37 46 43 83	38.35 44.87	9.66 11.30	3.18 3.72	1.60 1.87	10804 12641	 14525
[illegible]	[illegible]	8/12	Fulton	5	15 80 Dry	35 84 42 56	37.67 44.74	10.69 12.70	3.00 3.57	1.79 2.12	10460 12423	 14520
[illegible]	0811 [illegible]	8/12	Fulton	5	17 39 Dry	37 00 44 79	35.69 43.20	9.92 12.01	2.74 3.28	1.14 1.36	10273 12435	 14416
[illegible]	0811 [illegible]	8/12	Fulton	5	16 33 Dry	36 27 43 34	36.58 43.72	10.82 12.94	3.40 4.06	1.94 2.32	10246 12247	 14371
[illegible]	0811 [illegible]	8/12	Fulton	5	16 33 Dry	36 75 43 92	38.02 45.44	8.90 10 64	2.59 3.10	1.02 1.22	10604 12674	 14421
12436	0814	4 21	Fulton	5	15 88 Dry	33.96 40.37	38 75 46.07	11.41 13.56	4.38 5.21	.92 1.10	10330 12280	 14569
12437	0814	4 21	Fulton	5	16 68 Dry	35 46 42.56	37 90 45.49	9.96 11.95	3.82 4.58	.61 .74	10464 12559	 14579
12438	0814	4 21	Fulton	5	14.53 Dry	35.68 41.74	38.23 44.73	11.56 13.53	3.45 4.04	1.00 1.17	10608 12411	 14679
1404	0832	4/08	Fulton	5	15.09 Dry	35.39 41.68	38 89 45.80	10.63 12.52	3.21 3.79	....	10573 12450	 14447
5283	1116 C31	8/12	Fulton	5	15.18 Dry	37.17 43.82	35.17 41.45	12.48 14.73	3.45 4.07	1.70 2.00	10201 12026	 14441

TABLE 3—*Analyses of mine samples from District IV*—Continued

Lab No. (a	File No. (b	Date of analysis (c	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5284	1116 C31	8, 12	Fulton	5	16.94	35.68	37.15	10.23	2.98	1.31	10314	....
					Dry	42.95	44.73	12.32	3.59	1.57	12418	14446
5285	1116 C31	8 12	Fulton	5	18.42	34.98	37.66	8.94	2.33	.86	10270	.. ..
					Dry	42.88	46.15	10.97	2.85	1.06	12587	14371
5296	1116 C31	8 12	Fulton	5	16.82	37.28	33.45	12.45	2.84	1.69	10580	....
					Dry	44.81	40.23	14.96	3.42	2.02	12038	14479
5298	1116 C31	8 12	Fulton ...	5	16.52	37.17	36.54	9.77	3.91	.81	10394	....
					Dry	44.52	43.78	11.70	4.69	.97	12451	14409
5341	1116 C31	8 12	Fulton	5	17.37	35.71	37.86	9.06	2.34	1.14	10420	.. .. ..
					Dry	43.22	45.82	10.96	2.83	1.38	12610	14398
1856	1217a	9 08	Fulton ...	5	15.44	35.88	38.35	10.33	3.52	.	10711	.. ..
					Dry	42.42	45.36	12.22	4.17	....	12666	14673
4387	1220	8 11	Fulton	5	12.03	36.30	39.67	12.00	3.35	.72	10779	..
					Dry	41.27	45.08	13.65	3.81	.82	12254	14652
4388	1220	8, 11	Fulton ...	5	14.04	36.14	39.28	10.54	3.46	.56	10721	. .. .
					Dry	42.04	45.69	12.27	4.02	.65	12472	14627
2651	1220a	8 09	Fulton ...	5	14.35	34.48	36.98	14.19	4.44	.	10324	.. .
					Dry	40.25	43.18	16.57	5.19	....	12053	14771
1796	0521	9 08	Knox (d....	5?	14.55	38.25	40.37	6.83	4.31	...	11207	..
					Dry	44.75	47.26	7.99	5.05		13113	14528
1797	0521	9, 08	Knox ...	5?	14.54	37.73	40.57	7.16	4.47		11187	.
					Dry	44.15	47.46	8.39	5.24	.	13090	14578
1798	1132	9 08	Knox	5?	14.45	36.74	38.76	10.05	2.23	..	10820	–
					Dry	42.95	45.31	11.74	2.60	.	12645	14475
2769	0622	..	Knox. . .	6?	17.94	33.99	39.47	8.60	2.60		10367	.
					Dry	48.10	41.42	10.48	3.16		12632	14353
2756	1336	. ..	Knox ..	?	13.30	41.17	38.85	6.68	3.15		11603	
					Dry	47.85	44.81	7.71	3.63		13383	14721
5263	0730 C33	8/12	Logan . ..	5	14.64	37.87	35.56	11.93	3.60	1.10	10400	
					Dry	44.36	41.66	13.98	4.22	1.28	12183	14497
5264	0730 C33	8, 12	Logan. . . .	5	13.98	36.86	37.98	11.18	3.14	1.43	10549	
					Dry	42.84	44.16	13.00	3.65	1.67	12264	14391
5265	0730 C33	8 12	Logan	5	13.99	36.85	38.17	10.99	3.26	1.32	10519	...
					Dry	42.85	44.37	12.78	3.79	1.53	12230	14313
U. S. 2881(e	0730		Logan.	5	14.77	32.90	39.75	12.58	3.95		10406	
U. S. 2882(e	0730		Logan.	5	15.52	32.27	39.86	12.35	3.65			.
U. S. 3003(e	0730		Logan. .	5	15.68	32.41	39.82	12.09	3.51		10215	
720	0730	9, 07	Logan . .	5	14.80			11.76	3.03		10586	
					Dry	.		13.81	3.56		12426	14626
1809	1514	10, 08	Logan. .	5	11.83	36.45	40.92	10.80	2.98		10912	
					Dry	41.33	46.42	12.25	3.38		12376	14261

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d) The Knox County analyses were not included in making the averages for Table 4 because of the uncertainty of identification of the coals in that area.

e) U. S. Geological Survey Bull. 322, p. 103, 1908.

TABLE 3—*Analyses of mine samples from District IV*—Continued

Lab. No. (a	File No. (b	Date of analysis (c	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5426	1905 C100	8/12	McLean........	2	10.13 Dry	45.00 50.07	35.92 39.97	8.95 9.96	3.27 3.59	.74 .82	11710 13029	 14723
5427	1905 C100	8/12	McLean..	2	11.34 Dry	40.05 45.17	39.18 44.19	9.43 10.64	3.18 3.58	.90 1.01	11394 12851	 14643
5428	1905 C100	8/12	McLean...... ..	2	10.61 Dry	41.87 46.84	35.94 40.21	11.58 12.95	3.79 4.24	.92 1.03	11225 12557	 14752
5429	1905 C100	8/12	McLean..........	2	12.31 Dry	42.17 48.09	38.03 43.37	7.49 8.54	2.69 3.07	.94 1.07	11636 13270	 14722
5430	1905 C100	8/12	McLean........	2	12.00 Dry	42.00 47.73	37.96 43.14	8.04 9.13	2.37 2.70	1.23 1.40	11634 13220	 14759
5433	1905 C100	8/12	McLean........	2	11.27 Dry	42.17 47.53	39.27 44.25	7.29 8.22	2.91 3.28	1.12 1.26	11784 13279	 14684
1748	1905	8/08	McLean..	2	12.02 Dry	40.86 46.44	38.21 43.43	8.91 10.13	2.96 3.36	....	11419 12980	 14635
1749	1905	8/08	McLean........	2	12.56 Dry	39.44 45.10	35.70 40.84	12.30 14.06	4.15 4.74	....	10754 12299	 14591
US 3044[f]	0100	....	McLean..........	5	10.25	35.88	40.11	13.76	2.80	....	11149	....
US 3045[f]	0100	....	McLean........	5	9.88	35.99	38.22	15.91	3.15	....	....	....
5431	1905 C100	8/12	McLean....... .	5	12.88 Dry	38.84 44.58	35.80 41.09	12.48 14.33	3.60 4.14	1.17 1.35	10601 12168	 14544
5432	1905 C100	8/12	McLean.........	5	13.34 Dry	38.39 44.30	36.72 42.37	11.55 13.33	3.59 4.14	1.31 1.51	10743 12397	 14629
5434	1905 C100	8/12	McLean.	5	13.73 Dry	36.79 42.64	36.14 41.89	13.34 15.47	3.99 4.62	1.19 1.30	10399 12054	 14639
1847	1103	9/08	McLean.........	6?	14.15 Dry	37.00 43.08	37.23 43.38	11.62 13.54	2.42 2.82	....	10719 12485	 14607
5200	1114 C42	7/12	Macon..........	5	13.52 Dry	36.72 42.46	39.66 45.86	10.10 11.68	4.23 4.95	.09 .11	10646 12443	 14405
5201	1114 C42	7/12	Macon............	5	13.62 Dry	37.72 43.68	40.34 46.70	8.32 9.62	3.39 3.93	.00 .00	11046 12788	 14403
5202	1114 C42	7/12	Macon.	5	14.36 Dry	38.06 43.88	39.35 45.37	9.33 10.75	3.87 4.46	.19 .22	10963 12638	 14447
1569[a]	1114	6/08	Macon..........	5	13.91 Dry	37.00 42.95	39.33 45.72	9.76 11.33	3.29 3.82	....	10804 12549	....
5244	W1212 C41	7/12	Macon	5	14.76 Dry	35.46 41.60	38.08 44.67	11.70 13.73	3.24 3.81	.90 1.06	10390 12189	 14443
5245	W1212 C41	7/12	Macon............	5	14.54 Dry	36.33 42.51	38.01 44.47	11.12 13.01	3.47 4.06	.68 .79	10465 12244	 14385
5346	W1212 C41	7/12	Macon............	5	14.14 Dry	36.21 42.18	38.07 44.34	11.58 13.48	3.24 3.77	1.12 1.31	10493 12210	 14433
1874	W1212	10/08	Macon...........	5	14.07 Dry	37.10 43.19	36.66 43.99	10.17 11.82	3.68 4.28	....	10780 12545	 14470

f) U. S. Bureau of Mines Bull. 22, Part I, p. 85, 1913.

TABLE 3—*Analyses of mine samples from District IV*—Continued

Lab. No. [a]	File No. [b]	Date of analysis [c]	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
2604	1332	12/09	Macon	6	15.42 Dry	39.68 41.96	44.05 46.57	10.85 11.47	4.25 4.50	…… ……	11814 12492	…… 14396
1411	1814	4/08	Peoria	2	12.05 Dry	40.49 46.03	37.88 43.07	9.58 10.90	3.94 4.48	…… ……	11316 12866	…… 14698
1409	1224	4/08	Peoria	5	13.45 Dry	34.81 40.22	37.32 43.12	14.42 16.66	3.09 3.58	…… ……	10398 12014	…… 14636
US22982[g]	1510	……	Peoria	5	15.03	34.56	39.05	11.36	2.64	……	10490	……
US22983[g]	1510	……	Peoria	5	15.41	33.87	38.85	11.87	2.88	……	10386	……
US22984[g]	1510	……	Peoria	5	15.51	34.77	38.68	11.03	2.62	……	10489	……
US22985[g]	1510	……	Peoria	5	15.57	34.08	38.18	12.17	3.42	……	10283	……
5289	1610 C25	8/12	Peoria	5	14.23 Dry	36.65 42.73	37.04 43.18	12.08 14.09	3.39 3.96	1.55 1.81	10483 12220	…… 14553
5290	1610 C25	8/12	Peoria	5	14.54 Dry	37.41 43.77	37.32 43.67	10.73 12.56	3.27 3.82	1.18 1.38	10705 12526	…… 14625
5291	1610 C25	8/12	Peoria	5	16.00 Dry	36.46 43.41	37.28 44.38	10.26 12.21	3.65 4.35	.90 1.07	10583 12598	…… 14664
2642	1610	7/09	Peoria	5	16.16 Dry	35.41 42.23	39.52 47.14	8.91 10.63	2.38 2.84	…… ……	10895 12995	…… 14644
1410	1610	4/08	Peoria	5	14.73 Dry	35.92 42.13	36.74 43.09	12.61 14.78	3.38 3.97	…… ……	10451 12257	…… 14619
5303	1612 C26	8/12	Peoria	5	16.00 Dry	36.06 42.93	37.54 44.69	10.40 12.38	2.90 3.46	1.27 1.51	10515 12518	…… 14773
5304	1612 C26	8/12	Peoria	5	14.23 Dry	37.41 43.62	37.36 43.56	11.00 12.82	3.14 3.66	2.17 2.53	10573 12327	…… 14433
5305	1612 C26	8/12	Peoria	5	14.76 Dry	35.95 42.18	35.34 41.46	13.95 16.36	3.19 3.74	2.00 2.34	10173 11935	…… 14636
US21032[g]	1626	……	Peoria	5	15.66	34.74	40.38	9.22	2.64		10798	……
US21033[g]	1626	……	Peoria	5	15.38	34.51	39.48	10.63	2.75		10645	……
US21034[g]	1626	……	Peoria	5	15.34	34.25	40.80	9.61	3.11		10741	……
1485	1626	4/08	Peoria	5	14.29 Dry	34.79 40.60	37.67 43.94	13.25 15.46	2.71 3.16		10365 12094	14493
2644	1814	8/09	Peoria	5	15.41 Dry	35.33 41.77	38.57 45.59	10.69 12.64	3.60 4.25		10677 12622	14697
2643	1926	8/09	Peoria	5?	15.31 Dry	34.92 41.25	37.62 44.44	12.12 14.31	2.85 3.37		10497 12385	14685
2637	0424	7/09	Peoria	6	17.16 Dry	35.66 43.05	38.11 46.00	9.07 10.93	2.78 3.36		10465 12633	14371
2640	0103	7/09	Peoria	7	14.54 Dry	34.01 39.79	37.07 43.38	14.38 16.83	3.05 3.57		10155 11881	14493

g) U. S. Bureau of Mines Bull. 123, p. 35, 1918.

TABLE 3—*Analyses of mine samples from District IV*—Continued

Lab. No. (a	File No. (b	Date of analysis (c	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5187	0317	7/12	Sangamon........	5	14.82	37.18	38.22	9.78	4.30	.72	10693	....
	C40				Dry	43.65	44.87	11.48	4.52	.84	12541	14483
5188	0317	7/12	Sangamon........	5	16.05	35.58	38.04	10.33	4.18	.17	10413	....
	C40				Dry	42.38	45.32	12.30	4.98	.20	12404	14476
5189	0317	7/12	Sangamon........	5	14.31	37.31	38.20	10.18	4.21	.90	10655	....
	C40				Dry	43.54	44.58	11.88	4.91	1.05	12434	14251
5166	0436	7/12	Sangamon........	5	13.38	37.20	36.40	13.01	4.78	.96	10338	....
	C39				Dry	42.95	42.03	15.02	5.52	1.10	11934	14439
5167	0436	7/12	Sangamon........	5	13.35	36.64	37.12	12.89	4.80	.84	10348	....
	C39				Dry	42.27	42.85	14.88	5.53	.97	11942	14423
5168	0436	7/12	Sangamon........	5	13.19	38.44	36.47	11.90	4.61	1.05	10513	....
	C39				Dry	44.28	42.00	13.72	5.31	1.20	12110	14397
5128	0913	7/12	Sangamon........	5	14.08	37.38	37.56	10.98	3.97	.38	9471	....
	C37				Dry	43.51	43.71	12.78	5.17	.49	12337	14492
5129	0913	7/12	Sangamon........	5	13.86	37.11	39.05	9.98	2.57	.52	10726	....
	C37				Dry	43.08	45.34	11.58	4.07	.61	12451	14365
5118	1010	7/12	Sangamon........	5	16.05	35.82	37.14	10.99	3.55	.67	10330	....
	C36				Dry	42.66	44.25	13.09	4.22	.80	12306	14476
5119	1010	7/12	Sangamon........	5	15.53	36.36	38.05	10.06	3.86	.55	10522	....
	C36				Dry	43.04	45.05	11.91	4.57	.66	12457	14450
5120	1010	7/12	Sangamon........	5	14.45	37.46	38.27	9.82	3.59	.55	10704	....
	C36				Dry	43.79	44.73	11.48	4.19	.65	12512	14423
5196	1503	7/12	Sangamon........	5	14.25	37.25	37.07	11.43	4.76	.98	10414	....
	C38				Dry	43.44	43.24	13.32	5.55	1.15	12147	14381
5197	1503	7/12	Sangamon........	5	14.10	38.74	37.66	9.50	3.86	.75	10790	....
	C38				Dry	45.09	43.85	11.06	4.50	.87	12564	14415
5198	1503	7/12	Sangamon........	5	14.44	38.22	37.68	9.66	3.79	.63	10746	....
	C38				Dry	44.67	44.04	11.29	4.43	.73	12549	14435
5199	1503	7/12	Sangamon........	5	14.08	38.05	35.30	12.57	5.87	.60	10228	....
	C38				Dry	44.28	41.09	14.63	6.83	.69	11903	14366
5130	2421	7/12	Sangamon........	6	15.22	38.23	37.36	9.19	4.38	.38	10579	....
	C74				Dry	45.09	44.07	10.84	5.17	.45	12478	14301
5131	2421	7/12	Sangamon........	6	13.10	38.86	37.25	10.79	5.08	.41	10592	....
	C74				Dry	44.72	42.86	12.42	5.86	.47	12187	14268
5132	2421	7/12	Sangamon........	6	14.43	38.14	37.07	10.36	4.77	.40	10495	....
	C74				Dry	44.58	43.32	12.10	5.58	.47	12265	14292
5115	2515	8/12	Sangamon........	6	14.97	36.90	38.36	9.77	3.53	.59	10598	....
	C75				Dry	43.39	45.12	11.49	4.16	.67	12466	14361
5116	2515	8/12	Sangamon........	6	14.51	37.60	39.69	8.20	3.44	.22	10911	....
	C75				Dry	43.98	46.43	9.59	4.02	.25	12763	14373
5117	2515	8/12	Sangamon........	6	12.98	38.23	38.92	9.87	4.32	.56	10845	....
	C75				Dry	43.94	44.72	11.34	4.96	.65	12463	14368

TABLE 3.—*Analyses of mine samples from District IV*—Concluded

Lab. No. (a	File No. (b	Date of analysis (c	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
9708	0136	11/16	Schuyler	2	12.73	37.56	41.88	7.83	4.77	....	11621	....
					Dry	43.04	47.99	8.97	5.46	....	13316	14924
9709	0136	11/16	Schuyler	2	12.34	38.11	42.29	7.26	4.32	....	11841	....
					Dry	43.48	48.24	8.28	4.92	....	13507	15011
1812	0819	9/08	Schuyler	6	12.99	37.28	38.62	11.11	3.75	....	11057	....
					Dry	42.84	44.40	12.76	4.31	....	12709	14827
5277	0906a C27	7/12	Tazewell	5	14.71	37.46	38.57	10.26	3.51	1.15	10801	....
					Dry	40.06	44.03	11.91	4.07	1.33	12516	14500
5278	0906a C27	7/12	Tazewell	5	13.88	37.58	40.01	8.53	2.55	.95	11076	....
					Dry	43.64	46.45	9.91	2.96	1.10	12860	14499
5281	0906a C27	8/12	Tazewell	5	15.56	37.60	36.70	10.14	3.23	1.50	10552	....
					Dry	44.53	43.46	12.01	3.83	1.78	12496	14488
1412	0407	4/08	Tazewell	6	14.30	36.74	39.11	9.85	3.34	....	10875	....
					Dry	42.87	45.64	11.49	3.90	....	12690	14562
1413	0906a	4/08	Tazewell	6	14.35	36.95	38.04	10.66	3.02	....	10709	......
					Dry	43.14	44.41	12.45	3.53	....	12504	14482

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a) The analyses that have "US" laboratory numbers were made by either the U. S. Bureau of Mines or the U. S. Geological Survey, as indicated in following footnotes which make reference to their place of publication.

b) Analyses having the same file number are for a single mine. It should be remembered that as much dependence can not be placed on a single analysis from a given mine as may be placed on a group from one mine.

Analyses having "C" file numbers are republished from State Geological Survey Bulletin 29, and Illinois Mining Investigations Bulletin 3, and belong to a series made by J. M. Lindgren under the general supervision of Professor S. W. Parr of the University of Illinois, for those bulletins.

c) The Fulton County analyses that have April, 1921, as the date of analysis, were made on samples collected by or under the supervision of H. E. Culver of the Survey staff.

TABLE 4.—*Average analytical and heat values for No. 1, No. 2, No. 5, No. 6 and No. 7 coals by counties and for the district*

No. of analyses	No. of mines	County	Coal bed	Proximate analysis of coal 1st: "As rec'd," with total moisture. 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
				Moisture	Volatile matter	Fixed carbon	Ash				
		NO. 1 COAL									
3	1	Christian	1	11.31	38.89	40.94	8.86	2.35	.64	11603	....
				Dry	43.85	46.16	9.99	2.65	.72	13081	14717
4	1	Fulton	1	12.71	38.19	39.79	9.31	4.70	.62	11387	....
				Dry	43.77	45.61	10.62	5.37	.70	13052	14939
7	2	Average	1	12.11	38.49	40.29	9.12	3.69	.63	11479	....
				Dry	43.80	45.84	10.35	4.20	.71	13065	14844
		NO. 2 COAL									
4	1	Christian	2	12.61	38.39	41.43	7.42	3.32	.21	11601	....
				Dry	44.11	47.41	8.48	3.80	.24	14276	14746
1	1	Fulton	2	14.87	35.80	43.88	5.45	....	....	11641	....
				Dry	42.06	51.54	6.40	3.69	....	13674	14083
8	1	McLean	2	11.53	41.45	37.53	9.25	3.17	.98	11445	....
				Dry	47.12	42.43	10.45	3.57	1.10	12936	14686
1	1	Peoria	2	12.05	40.49	37.88	9.58	3.94	....	11316	....
				Dry	46.03	43.07	10.90	4.48	....	12866	14698
2	1	Schuyler	2	12.54	37.81	42.09	7.55	4.55	....	11731	....
				Dry	43.26	48.12	8.63	5.19	....	13412	14968
16	5	Average	2	12.16	39.92	39.49	8.36	3.44	.72	11524	....
				Dry	45.50	44.99	9.50	3.89	.81	13122	14701
		NO. 5 COAL									
48	14	Fulton	5	15.36	35.04	38.00	10.90	3.13	1.48	10421	....
				Dry	41.95	44.90	13.14	3.68	1.70	12295	14465
8	2	Logan	5	14.40	35.09	38.87	11.71	3.39	1.28	10512	....
				Dry	42.85	44.15	13.16	3.72	1.49	12296	14418
5	2	McLean	5	12.02	37.18	37.40	13.41	3.43	1.22	10723	....
				Dry	43.84	41.78	14.38	4.30	1.39	12206	14572
8	2	Macon	5	14.14	36.83	38.69	10.26	3.55	.50	10698	....
				Dry	42.56	45.14	11.93	4.14	.58	12451	14427
18	6	Peoria	5	15.09	35.39	38.17	11.34	3.04	1.51	10536	....
				Dry	42.33	43.98	13.69	3.71	1.77	12372	14616
15	5	Sangamon	5	14.35	37.30	37.57	10.78	4.16	.59	10555	....
				Dry	43.55	43.86	12.59	4.86	.69	12323	14415
3	1	Tazewell	5	14.72	37.55	38.43	9.64	3.09	1.20	10810	....
				Dry	42.74	44.65	11.28	3.62	1.40	12624	14496
105	37	Average	5	14.83	35.73	38.05	11.07	3.33	1.24	10497	....
				Dry	42.43	44.49	13.01	3.95	1.43	12326	14474

TABLE 4—Concluded

No. of analyses	No. of mines	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO_2	B. t. u.	Unit coal
				Moisture	Volatile matter	Fixed carbon	Ash				
				NO. 6 COAL							
1	1	**Macon**	6	15.42 Dry	39.68 41.96	44.05 46.57	10.85 11.47	4.25 4.50	....	11814 12492	 14396
1	1	**Peoria**	6	17.16 Dry	35.66 43.05	38.11 46.00	9.07 10.95	2.78 3.36	....	10465 12633	 14371
6	2	**Sangamon**	6	14.20 Dry	37.99 44.28	38.11 44.42	9.70 11.30	4.26 4.96	.42 .49	10671 12437	 14329
1	1	**Schuyler**	6	12.99 Dry	37.28 42.84	38.62 44.40	11.11 12.76	3.75 4.31	....	11057 12709	 14827
2	2	**Tazewell**	6	14.33 Dry	36.85 43.01	38.58 45.03	10.26 11.97	3.18 3.72	....	10297 12597	 14522
11	7	**Average**	6	14.49 Dry	37.66 43.60	38.78 44.87	9.97 11.54	3.88 4.49	.42 .49	10813 12514	 14418
				NO. 7 COAL							
1	1	**Peoria**	7	14.54 Dry	34.01 39.79	37.07 43.38	14.38 16.83	3.05 3.57	....	10155 11881	 14493

TABLE 5.—*Average analyses of Illinois coals by districts*

(Figures are for coal as received)

Analyses by J. M. Lindgren under general supervision by Prof. S. W. Parr

District	Coal bed	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	B. t. u.	Number of samples averaged
LaSalle	2	16.18	38.83	37.89	7.08	2.89	10981	33 from 11 mines
Murphysboro	2	9.28	33.98	51.02	5.72	1.29	12488	15 from 5 mines
Rock Island and Mercer counties	1	13.46	38.16	39.75	8.63	3.59	11036	14 from 4 mines
Springfield-Peoria ([a])	5	15.10	36.79	37.59	10.53	3.52	10514	54 from 17 mines
Saline County	5	6.75	35.49	48.72	9.04	2.92	12276	27 from 7 mines
Franklin and Williamson counties	6	9.21	34.00	48.08	8.71	1.53	11825	58 from 16 mines
S. W. Illinois west of Duquoin anticline	6	12.56	38.05	39.06	10.33	4.01	10847	76 from 25 mines
Danville: Grape Creek coal	6	14.45	38.29	38.75	9.98	2.93	11143	18 from 2 mines
Danville: Danville coal	7	12.99	38.29	38.75	9.98	2.93	11143	18 from 2 mines

[a] The difference in the average analysis here given from that given in Table 4 is explained by the fact that (1) a somewhat larger area is covered by Table 4, and (2) more analyses have been used in arriving at the Table 4 average, some of them from the United States laboratories, and others made very recently.

STRUCTURE

The structure of the several counties covered by this report is discussed in some detail by county units in Part II. For the convenience of those interested in the structure of District IV as a whole, Plates I and III have been prepared.

On the map, Plate I, structure contours on the top of No. 5 coal show the lay of the rock in the area as closely as it can be determined from a study of outcrops and available drill and shaft records. The locations of all the active shipping mines in the district and of such other mines and borings as gave information useful in the preparation of the map, are also shown, as well as the position of the outcrop of No. 5 coal.

Plate III consists of three structure sections, two approximately east and west and one north and south across the district.

The numbered red lines on the map, Plate I, are structure contours on No. 5 coal. Any given contour connects all known points where the elevation of No. 5 coal is the same and the numbers on the lines state that elevation. In Plate I, the contour interval used west of Illinois River is 25 feet, which means that between any two adjacent contours the coal bed dips more or less uniformly from the higher elevation to the lower. East of the Illinois the interval is 50 feet, and a fifty-foot change in elevation from one contour to the next is implied.

Study of the structure shown on the map shows that the general regional dip is to the southeast, from 650 feet above sea level in south-central Knox County to only 50 feet above sea level in southeastern Mason County.

This regional dip in the direction of the major synclinal basin that roughly parallels the La Salle anticline. In Eastern McLean County is found the only exception to the general regional dip—there the strata are beginning to rise, as shown by the No. 5 coal contours, to form the west flank of the La Salle anticline.

It will be noticed that the contours are more irregular in Peoria, Fulton, and Sangamon counties than in the remainder of the area. This difference does not mean that in those counties dips are more variable than they are elsewhere; in all probability irrgularities of the same sort characterize the whole district, but outside the counties mentioned, well logs and outcrops are so few and scattered that it was not possible to work out details of structure.

PART II.—COUNTY REPORTS

INTRODUCTION

The detailed description of the geological conditions in the district as affecting mining is thought to be most conveniently presented by the county unit. County reports are therefore presented in alphabetical order in the following pages.

A complete list of shipping mines in District IV for the year 1920 is given herewith as table 6.

TABLE 6.—*List of shipping mines in District IV, 1920*

Map No.	Name of company	No. or name of mine	Location ¼	¼	Sec	T. N.	R.	Surf. elev.	Depth to No. 5 coal(a)	Alt. of top of coal	No. of coal	Thickness		Production 1917(b)	Production 1920(b)
	Fulton County								*Feet*			*Ft.*	*in.*		
1	Alden Coal Co.	No. 5	Cent.	N½	2	8	4 E.	745	185	560	5	4	4	120,020	4,826
2	Alden Coal Co.	No. 6	NW	SW	27	8	4 E.	762	190	572	5	4	3	127,839	115,105
3	Alden Coal Co.	No. 8	Cen.	SE	3	8	4 E.	680 ±	70	610	5	4	0	163,876	143,979
4	Big Creek Coals, Inc.	No. 2	SE	SW	16	6	4 E.	578		578	5	5	0	300,127	238,400
5	E. G. Bader	Eclipse	NW	SE	14	3	1 E.								21,259
6	Big Creek Coal Co. (abandoned)	No. 3	SE	NE	20	6	3 E.	683	55	628	5	5	2	113,717	
7	Big Creek Coals, Inc.	No. 4	NE	SE	22	6	4 E.	637?	82	555?	5	5	6	207,007	158,390
8	Big Six Coal Co.	Big Six	NE	NW	31	8	3 E.		drift	635 ±	5	4	0		
9	Binzel Coal Co.	No. 1 (Binzel)	NW	SE	4	8	4 E.	660 ±	41	620	5	4	8		36,953
10	Canton Coal Co.	No. 1	NW	SW	34	8	4 E.	740	180	560	5	4	1		154,973
11	Coal Creek Mining Co.	Parrville	NW	SW	30	8	3 E.		drift	638	5	4	0	41,930	24,035
12	Cripple Creek Coal Co.	No. 1	SW	SW	24	6	3 E.		drift		5	4	8		200,338
13	Cripple Creek Coal Co.	No. 2	SW	SW	24	6	3 E.		drift		5				
14	Eagle Mining Co.	Eagle	SE	SE	32	7	4 E.	683	103	580	5	4	10	128,085	91,021
15	Genuine Norris Coal Mining Co.	Genuine Norris	SE	SE	34	8	4 E.	735	180	555	5	4	1	66,129	
16	Maplewood Coal Co.	No. 1	SE	NW	11	8	4 E.	720	122	598	5	4	2	78,441	77,503
17	Maplewood Colliery Co.	No. 2	NW	SE	15	8	4 E.	760	146	614	5	4	2	132,053	60,250
18	Middleton Coal Co.	Middleton	NE	SW	33	7	4 E.	660	60	600	5	4	8		35,957
19	Monmouth Coal Co.	No. 1	NW	NW	11	7	4 E.	705 ±	142	563 ±	5	4	6	172,413	136,304
20	National Coal Mining Co.	National	SE	SW	5	8	4 E.	710	105	605	5	4	0	150,074	155,551
21	Rawalt Coal Co.	Rawalt	NE	NE	36	7	4 E.	655	76	579	5	4	8		20,667
22	Shuler and Long	Parrville	NW	NW	31	8	3 E.								7,021
23	Silver Creek Colliery Co.	No. 1	SW	SE	4	8	4 E.	675	41	634	5	4	0	279,708	186,798
24	Simmons Coal Co.	Simmons	SW	SW	14	7	4 E.	682	121	561	5	4	6	137,674	88,216
25	Spoon River Colliery Co.	Ellisville: No. 1	NE	SW	28	8	2 E.		36(c)		1	4	6	102,239	78,405
26	Star Coal Co.	Fiatt: No. 1	NW	SW	28	7	3 E.	687	56	631	5	4	10	37,000	41,721
27	Star Coal Co.	No. 3	NW	SE	20	6	3 E.	659	26	633	5	4	11	147,278	64,449
	Logan County														
1	Citizens Coal Mining Co.	Citizens	SW	NW	32	20	2 W.	590	266	324	5	5	0	177,849	155,223
2	Latham-Lincoln Mining Co.	Latham	SE	NE	30	20	2 W.	600 ±	280	320 ±	5			256,642	239,877
3	Lincoln Mining Co. (abandoned)	No. 1	SE	NE	36	20	3 W.	587	280	307	5	5	0	162,020	

(a) Unless otherwise specified

(b) For the fiscal year; as reported to the Department of Mines and Minerals and published in the annual coal reports.

(c) No. 1 coal

TABLE 6.—*List of shipping mines in District IV, 1920*—Continued

Map No.	Name of company	No. or name of mine	Location					Surf. elev.	Depth to No. 5 coal(a)	Alt. of top of coal	No. of coal	Thickness		Production 1917(b)	Production 1920(b)
			¼	¼	Sec.	T. N.	R.								
	Macon County								*Feet*			*Ft.*	*in.*		
1	Decatur Coal Co.	No. 2	NE	NW	14	16	2 E.	....	610	....	....	4	0	73,937	90,504
2	Macon County Coal Co.	No. 1	W½	SW	14	16	2 E.	685 ±	555	130	5	4	3	180,105	121,904
3	Niantic Carbon Coal Co.	Niantic	SW	NW	12	16	1 W.	603 ±	360	243	5	5	6	4,962	6,412
	McLean County														
1	McLean County Coal Co.	McLean Co.	NW	SE	5	23	2 E.	785	375	410	5	4	6		
2	C. H. H. Fisher, Receiver	Colfax: No. 1	SE	SE	3	24	5 E.	750	513(d	272	2	3	6	77,083	43,357
									406(e	344	6?	5	5	12,329	....
	Menard County														
1	Union Fuel Co.	No. 4: Athens	SW	NW	36	18	6 W.	605	203	402	5	5	8	155,878	99,114
	Peoria County														
1	Clark Coal and Coke Co.	Empire: No. 2	SW	SE	10	8	7 E.	650 ±	181	469	5	4	0	232,594	243,559
2	Collier Cooperative Coal Co.	No. 1	SE	NE	26	8	7 E.	635 ±	106	529	5	4	3	61,314	41,360
3	Crescent Coal Co.	No. 1	SE	NW	12	8	7 E.	470	196	274	5	4	6	158,340	138,575
4	East Mapleton Coal Co.	No. 1	SW	SE	19	7	7 E.	472	22¼ (drift)	450 ±	5	4	6	28,454	....
5	East Mapleton Coal Co.	East	NE	SE	20	7	7 E.	450 ±	drift	450 ±	5	5	0	....	....
6	John A. Hoffman	Blue Fly	NW	SW	36	9	7 E.	465	106d	359	2	2	6	....	....
7	Lancaster Coal Co.	No. 1: Kingston	SW	NE	27	7	6 E.	....	drift	....	5	4	5	26,122	23,209
8	Leitner Coal Co.	Leitner	NW	NW	12	7	7 E.	460?	17 (drift)	443	5	4	8	27,619	27,597
9	Logan Coal Co.	No. 1	NE	SE	10	8	6 E.	735?	236?	499?	5	....	....	118,466	101,708
10	M. E. Case Coal Co.	Walben: No. 1	SE	NW	1	7	7 E.	487	16 (drift)	471	5	4	2	221,254	105,505
11	Newsam Bros.	Glasford: No. 4	NE	NE	28	7	6 E.	615?	148?	467?	5	4	6	110,587	112,311
12	Newsam Bros.	LaMarsh: No. 5	NE	NE	8	7	7 E.	....	....	....	5	4	6	....	55,262
13	Warsaw Coal Co.(f)	Warsaw	NE	NW	24	9	6 E.	625	....	....	5	4	4	94,256	70,488
14	Wolschlag Cooperative Coal Co.	Wolschlag	NE	SW	36	8	7 E.	....	....	....	5	...	....	273,315	131,661
	Sangamon County														
1	Bissell Coal Co.	Bissell	NW	SW	8	16	4 W.	568	235	334	5	5	6	20,657	153,934
2	Chicago-Springfield Coal Co.	C-S	SW	NW	12	16	5 W.	565	230	335	5	6	2	347,523	182,082
3	Chicago, Wilmington & Franklin Coal Co.	Thayer	SW	SW	34	13	6 W.	648	300	348	6	7	0	....	568,001

(d) No. 2 coal.

(e) Identification of coal uncertain; possibly No. 6.

(f) In the SW. ¼ of this section, the Warsaw Coal Company has two drift mines, No. 3 and No. 4, which are run as one mine, the tipple being in the NW. ¼.

TABLE 6. *List of shipping mines in District IV, 1920* Concluded

Map No.	Name of company	No. or name of mine	Location ¼	Location ¼	Location Sec.	Location T. N.	Location R.	Surf elev.	Depth to No. 5 coal (a)	Alt. of top of coal	No. of coal	Thickness Ft.	Thickness in.	Production 1917 (b)	Production 1920 (b)
									Feet						
4	Citizens Coal Mining Co.	"A"	NW	NW	32	16	5 W.	590 ±	207	383 ±	5	5	4	60,458	171,331
5	Citizens Coal Mining Co.	"B"	SW	SE	31	16	5 W.	605 ±	204	401 ±	5	5	9	235,947	193,020
6	Dawson Coal Mining Co.	Dawson	NW	NW	8	16	3 W.	597	250	347	5	5	2	58,507	106,941
7	Illinois Coal & Coke Corporation	No. 400	SW	SW	14	16	5 W.	582	244	338	5	5	9	219,513	199,527
8	Lincoln Park Coal & Brick Co	Lincoln Park	SE	SW	21	16	5 W.	569	204	365	5	5	9	98,846	101,331
9	Madison Coal Corporation	No. 6	NE	SW	21	13	5 W.	610 ±	330	280	6	....	....	....	777,561
10	Panther Creek Mines, Inc	Panther Creek	NE	NE	35	14	6 W.	....	....	....	6	....	....	....	318,752
11	Peabody Coal Co	No. 5	SW	NE	12	13	5 W.	628	322	306	6	6	0	....	183,238
12	Peabody Coal Co.	No. 6	SE	SE	36	17	5 W.	550	198	352	5	6	0	429,721	379,052
13	Peerless Coal Co.	Peerless	NW	SW	13	16	5 W.	580	223	357	5	5	10	450,455	420,061
14	Sangamon Coal Co.	Sangamon: No. 2	NE	NE	26	16	5 W.	592?	250?	342?	5	5	10	330,339	348,602
15	Sangamon Coal Co.	No. 3	SE	NW	8	17	5 W.	602	206	396	5	6	1	25,082	36,803
16	Sangamon County Mining Co.	Jefferson	NW	SW	1	15	5 W.	582	240	342	5	5	9	84,313	224,422
17	Spring Creek Coal Co.	Spring Creek	NW	SE	19	16	5 W.	....	....	....	5	....	....	143,463	196,496
18	Springfield Cooperative Coal Co.	Cooperative	NW	NW	23	16	5 W.	585	245	340	5	....	....	191,800	164,730
19	Springfield District Coal Mining Co.	Cora: No. 51	SW	SE	27	17	5 W.	530	145	385	5	....	....	197,698	145,104
20	Springfield District Coal Mining Co.	No. 52	NW	SE	10	16	4 W.	550	232	318	5	5	11	500,517	323,621
21	Springfield District Coal Mining Co.	Woodside: No. 53	NW	SW	3	15	5 W.	600	245	355	5	6	6	296,983	278,081
22	Springfield District Coal Mining Co.	No. 54 (Black Diamond)	SW	SE	15	13	6 W.	603	244	359	6	....	....	....	350,190
23	Springfield District Coal Mining Co.	No. 55	SW	NW	9	15	5 W.	607	250	357	5	5	11	320,295	276,768
24	Springfield District Coal Mining Co.	Capital: No. 57	NE	NW	35	16	5 W.	598	220	378	5	6	0	213,201	161,760
25	Union Fuel Co.	No. 2	SE	NE	6	15	4 W.	575 ±	220	350	5	5	8	180,711	141,065
26	Union Fuel Co.	No. 3	NE	NE	10	13	6 W.	628	264	364	6	6	8	....	168,873
27	Union Fuel Co.	No. 5	SE	NW	17	17	4 W.	590	267	323	5	5	8	....	14,193
28	West End Coal Co.	West Shaft	SE	NE	29	16	5 W.	530	145	385	5	5	10	283,673	231,060
	Tazewell County														
1	Groveland Coal Mining Co.	No. 1	SW	NW	7	25	4	535?	85	450?	5	4	4	217,491	201,370
2	Groveland Coal Mining Co	No. 2	NE	NE	18	25	4	614	165	449	5	4	4	....	568,001
3	Johnston City Big Muddy Coal and Mining Co.	No. 3	NW	NW	6	24	4	600	205	395	5	4	8	....	21,007
4	Lake Erie Mining Co.	Lake Erie	NW	NE	6	25	4	....	....	....	5	4	4	27,883	88,007
5	Tazewell Coal Co.	Tazewell	SW	NW	6	24	4	580	162	418	5	4	8	146,627	112,540
6	Ubben Coal Co.	Ubben	SE	SW	1	24	5	540	100	440	5	4	10	29,000	36,696

CASS COUNTY

PRODUCTION AND MINES

Production in tons, year ended June 30, 1920	4,233
Average annual production, 1916 to 1920	1,858
Total production, 1881 to 1920	155,785

The production in 1920 came from four local mines, two along the Illinois valley bluff near Beardstown, one at Chandlerville, and one at Ashland. These mines are all small, so that the resources of this county are essentially untouched.

COAL-BEARING ROCKS

All of Cass County is underlain by "Coal Measures" strata except for the area between Illinois River and its valley bluff, and in the lower part of the Sangamon valley, below Chandlerville, where the "Coal Measures" have been entirely eroded, so as to expose the underlying Mississippian limestone.

Since the line of outcrop of No. 5 coal nearly coincides with the eastern boundary of the county, it is believed that most of the area is underlain by Pennsylvanian strata older than No. 5 coal, that is by strata of lower Carbondale and Pottsville age. These formations contain at least one and probably two beds of coal neither of which, apparently, is more than three feet thick. The most widespread of these coals is the No. 2 (Colchester, Murphysboro, or La Salle "Third Vein") coal which outcrops along the Illinois and Sangamon valley bluffs between Bluff Springs and Chandlerville, and has been mined at Virginia at a depth of about 200. It is probably this same bed which at one time was mined at Ashland at a depth of 205 feet.[1] As the identity of this coal is not determined, and as it may be younger than No. 2, it may be the same as a bed encountered in a drill hole just south of Springfield, between 50 and 60 feet below No. 5 (Springfield) coal.

The character of the strata with which the coals are interbedded is not well known. Worthen[2] reports the following succession taken at an old shaft near Bluff Springs:

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[1] Third Biennial Report of the Bureau of Labor Statistics, p. 506, 1884.
[2] Geological Survey of Illinois. Vol. 4. p. 165, 1870.

Section of Pennsylvanian strata near Bluff Springs, Cass County

		Thickness *Feet*	Depth *Feet*
1.	Soil (loess)	15	15
2.	Sandstone, brownish, with plant impressions	13	28
3.	Limestone ("blue rock")	2	30
4.	Clay shale ("soapstone")	12	42
5.	Coal	3	45
6.	Fire clay, very hard	4	49

The sandstone, No. 2 of the above section, can be traced along the bluff northeastward nearly to Chandlerville, and it is present in the shaft at Virginia with a thickness of 70 feet, as may be noted in the following drill record of a coal prospect at that place.

Record of a boring for coal at Virginia, Cass County, Illinois[1]

Description of Strata		Thickness		Depth	
		Ft.	*In.*	*Ft.*	*In.*
Quaternary system—					
Pleistocene and Recent—					
Soil, and clay, brown		7	....	7	....
Clay, yellow		2	6	9	6
Clay, blue		29	8	39	2
Hardpan		28	....	67	2
Forest bed (ancient soil)		3	....	70	2
Hardpan		44	10	115	....
Pennsylvanian system—					
Sandstone		71	11	186	11
Limestone, hard		1	1	188	....
Shale, black		2	6	190	6
Shale, clay		10	3	200	9
Coal (No. 2) (base of Pottsville)		3	6	204	3
Fire clay		3	....	207	3
Shale, black		....	3	207	6
Shale, clay		7	6	215	....
Clay, "potter's"		13	....	228	....
Coal		....	2	228	2
Sandstone and shale		6	1	234	3
Coal	Horizon of No. 1	....	3	234	6
Sandstone and shale		6	9	241	3
Coal		....	8	241	11
Sandstone and shale		16	4	258	3
Coal		....	3	258	6
Sandstone		2	9	261	3
Coal		....	2	261	5
Sandstone and shale		3	9	265	2
Clay shale		4	....	269	2

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[1] Geological Survey of Illinois, Vol. 7, p. 15, 1883.

Record of a boring for coal at Virginia, Cass County—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Sandstone	7	5	276	6
Rock, hard siliceous	2	....	278	7
Clay shale	2	6	281	1
Rock, hard siliceous	3	6	284	7
Shale, hard green	2	10	287	5
Mississippian system—				
St. Louis and Warsaw—				
Shale, hard green	2	10	287	5
Limestone	9	1	296	6
Sandstone	1	8	298	2
Limestone	62	4	360	6
Sandstone	8	....	368	6
Limestone, gray	1	....	369	6
Sandstone	2	....	371	6
Limestone	2	3	373	9
Sandstone	18	....	391	9
Keokuk—				
Clay shale, drab	6	6	398	3
Shale, sandy	5	3	403	6
Limestone, shaly	4	1	407	7
Quartz band	....	4	407	11
Limestone, shaly	3	8	411	7
Shale, clay	....	6	412	1
Limestone, shaly	16	9	428	10
Flint band, yellow	....	1	428	11
Shale, clay	3	7	432	6
Limestone, hard gray	4	1	436	7
Limestone, shaly	6	2	442	9
Shale, with bryozoans	2	2	444	11
Limestone, shaly	4	7	449	6

The correlation of the coal mined at Bluff Springs and Virginia is based upon comparisons made by Worthen,[1] who points out the similarity of this coal to the coal mined and outcropping at Exeter, Scott County. Observations by the writer in Scott County indicate that the coal at Exeter and Alsey is the same coal as that mined near Roodhouse and Whitehall in Greene County and at Upper Alton in Madison County, and is to be correlated with the No. 2 coal. This coal in southwestern Illinois has a roof of black paper-shale, commonly called "slate" which has a variable thickness up to about 20 feet; but in certain areas, especially toward the north, gray shale or "soapstone" lies between the coal and "slate." About 5 feet below the coal is a bed of limestone 2 to 5 feet thick, known locally as the "sump rock." These relationships render the identification of the No. 2 coal very definite throughout the southwestern part of the coal basin, so that there is not much doubt as to the correlation of the coal at Bluff Springs, provided it is the same as the coal at Exeter.

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[1] Worthen, A. H. Geological Survey of Illinois, Vol. 4, p. 173.

DIP OF THE ROCKS

In Cass County the coal-bearing strata dip at a low angle to the east, at the rate of 8 to 10 feet per mile. Thus, coal which outcrops along the bluff east of Beardstown is at a depth of about 200 feet at Virginia and, provided the coal formerly mined at Ashland is No. 2, possibly 50 feet lower at Ashland. Because of the eastward dip, younger and younger rocks underlie the glacial material in that direction, so that the outcrop of the No. 5 or Springfield coal nearly coincides with the east line of the county.[1] Whether or not there are large irregularities or significant interruptions in the general eastward dip is not known. In general it is believed unlikely that there are any irregularities in the "lay" of the coal that will seriously interfere with mining.

NO. 2 COAL

The principal coal of Cass County is undoubtedly the No. 2 bed, which underlies all the county east of Illinois valley, probably crossing the Sangamon valley near Chandlerville. This coal is commonly between 3 and 3½ feet in thickness, and elsewhere possesses great regularity in thickness and in physical characteristics, though very little is known as to its physical characteristics in this county. It is probable, however, that the coal has the usual gray shale or black "slate" roof found above No. 2 coal in adjacent counties to the south and west, a description of which is given in some detail in the chapter assigned to the resources of Fulton County. An analysis of No. 2 coal made from a sample collected in Schuyler County may also be found in the same section.

Because this coal is relatively so thin and its area of outcrop so small that mining by drift or slope entrance is practicable in only a small part of the county, the development of the coal resources in Cass County is probably not a matter of immediate concern. Diamond drilling should precede future development, as the data available are entirely too meager to justify undertaking mining operations.

As the rock surface below the drift is more or less irregular, it is not improbable that isolated and local areas of No. 5 coal may be present in places in the eastern part of the county, west of the principal line of outcrop.

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[1] Shaw, E. W., and Savage, T. E., U. S. Geological Survey Geol. Atlas: Tallula-Springfield Folio (No. 188), Areal geology sheet, 1913.

The correlation of the coal found between Ashland and Prentice in Morgan County, as shown in the record of drilling near Prentice given below, is uncertain.

Drilling near Prentice, Morgan County

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian system—				
"Slate," rotten black	2	6	2	6
Coal	....	2	2	8
Fire clay	12	4	15	....
Shale	1	....	16	....
Coal	....	2	16	2
Fire clay	1	3	16	5
Sandstone and shale	16	7	34	....
Shale, with bands of ironstone	56	....	90	....
"Slate," black (fossiliferous)	3	10	93	10
Sandstone, soft	15	....	108	10
Shale	14	....	122	10
Limestone	1	...	123	10
"Slate"	2	....	125	10
Coal (No. 2?)	2	10	128	8
Fire clay	6	....	134	8

The stratigraphic succession is more suggestive of strata associated with No. 2 than with any other coal, but such a correlation would possibly give an unusual altitude to the coal at this place.

No analyses of the coal in Cass County are available.

CHRISTIAN COUNTY

Only the northern part of Christian County from Edinburg northward is included in the area of this report. The Greenwood Coal Company at this place mines No. 5 coal. This is the farthest south that this coal is worked in the central part of the State.

Coal-bearing Rocks

The geology of Christian County has been adequately discussed in Illinois Mining Investigations Bulletin 11, Coal Resources of District VII, and no additional data can be added relative to the coal in the northern part of the county. However, the following paragraphs may fitly be quoted from Bulletin 11:

"The coals below No. 6 are lenticular and hence less easily traceable. Moreover, the interval between the beds, especially between No. 5 and No. 6 coals, varies considerably in short distances, thus adding to the difficulty of correlation. For example, the interval between No. 6 coal and the next lower important coal varies from 20 feet in the vicinity of sec. 34, T. 14 N., R. 2 W., to about 75 feet in sec. 13, T. 13 N., R. 2 W. The lower bed ranges in thickness from 1 foot to 5 feet and averages 3½ feet in eight diamond drill holes in the townships mentioned. It is probable that it should be called No. 5 coal since the larger interval is not uncommon in the counties south of Christian, and the smaller one is well known to the north as in the mine at Mechanicsburg. Even at Springfield the average interval between No. 5 and No. 6 coals is but 39 feet. This bed tends to become thicker toward the north, and in secs. 13, 22, 32 and 34, T. 14 N., R. 2 W., No. 5 and No. 6 coals are of about equal importance. In a majority of the holes the roof of No. 5 coal is composed of a few feet of black shale capped by a thin limestone, this succession of beds being the normal one in the Springfield district, where No. 5 coal is mined. Near Edinburg and Sharps the cap-rock is absent.

"* * * Three main horizons appear to exist below No. 5 coal. Owing to the lenticular nature of the coal it is not believed that all three horizons contain commercial coals throughout the county. * * * The lenticular character of (these) coal beds renders predictions unsafe, but the existence of coals that may prove to be commercial, as at Assumption, is highly probable. With this in mind it seems reasonable to suggest that * * * a few holes should be continued from 250 to 300 feet below No. 6 coal in order to test all the possibilities of the area."[1]

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[1] Kay, Fred H. Coal Resources of District VII: Illinois Mining Investigations Bull. 11, pp. 80-81, 1915.

DEWITT COUNTY

INTRODUCTION

DeWitt County lies across the trough of the Illinois coal basin. It is the only county in District IV in which coal has never been mined, nor is coal of workable thickness definitely known to underlie it.

SURFICIAL DEPOSITS

Special attention should be directed to the excessive thickness of the glacial drift which so effectively covers the hard rocks in DeWitt County that "Coal Measures" outcrops are unknown. The few deep drillings that have been made, records of which are reproduced above, show thicknesses of glacial material of from 163 to 350 feet. Leverett[1] states that the average thickness of the drift is probably more than 200 feet. The following data, compiled from Leverett's report, will give some idea of the thickness of the drift at various places in the county.

Thickness of the drift in De Witt County

Town	*Depth of Well*	*Terminal strata*	*Depth of rock entered*
Farmer City (city well)	176	sand	...
Farmer City (coal prospect).....	...	...	189
Parnell	200	...	...
Clinton (water wells)	80-100	sand and gravel	...
Clinton (coal boring)	...	...	352
Clinton (coal boring)	...	...	270
Clinton (Barnett's gas well, 8 miles west)	137	sand	...
Hallsville (several gas wells).....	117-127	sand	...
Kenney	291	sand and gravel	...
Waynesville (city wells)..........	150?	...	...
Wapella (water wells.............	80-100	till or sand	...
Maroa (Macon County)	...	...	270

The lower part of the drift commonly contains considerable sand and gravel, and some loose sand or quicksand, which are water-bearing and therefore sources of difficulty to be guarded against in shaft sinking. Furthermore, buried muck and peat beds and associated sands contain inflammable gas derived probably from the muck, and such beds would also probably be a source of considerable inconvenience and risk in opening mines.

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[1] Leverett, Frank, Illinois Glacial Lobe: U. S. Geological Survey Mon. 38, p. 705, 1899.

COAL-BEARING ROCKS

As has been said, coal of workable thickness is not definitely known to underlie DeWitt County. An unsubstantiated record of an old boring at Farmer City reproduced herewith reports 4 feet 4 inches of coal at 564 feet and 4 feet 9 inches at 665 feet. It is possible that the upper of these coals is No. 7, and the lower, No. 5; No. 6 being represented by a 9-inch bed at 606 feet. If the suggested correlations of the coal are correct, it is possible that the limestone beds between 300 and 340 feet represent the Carlinville limestone.

Record of drilling at Farmer City, T. 21 N., R. 5 E., DeWitt County

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Soil	2		2	
Clay, yellow	9		11	
Clay, blue	36		47	
Quicksand	2		49	
Clay, blue, and gravel	6		55	
Clay, blue, and gravel	15		70	
Sand and gravel	40		110	
Clay, blue	6		116	
Sand and gravel	8		124	
Clay, blue, and sand	40		164	
Sand and gravel	10		174	
Quicksand	13		187	
Clay, blue	2		189	
Pennsylvanian system—				
McLeansboro—				
Sandstone	4		193	
Sand shale	11		204	
Shale, red	2		206	
Shale, blue		4	206	4
Shale, calcareous	2	8	209	
Shale, blue	1		210	
Shale, red	8		218	
Shale with limestone seams	2		220	
Sand shale	17		237	
Shale, black	3		240	
Coal	1	2	241	2
Clay shale	39	6	280	8
Clay shale	8		288	8
Shale, blue	4		292	8
Limestone	8		300	8
Shale, black	2		302	8
Shale, red and gray	9		311	8

Record of drilling at Farmer City—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Limestone	2	...	313	8
Sand shale	5	....	318	8
Limestone	4	...	322	8
Shale, blue	18	....	340	8
Sand shale	10	....	350	8
Shale lime	10	....	360	8
Shale, red	5	....	365	8
Shale, red	6	....	371	8
Sandstone	16	....	388	8
Sandstone, soft	20	....	408	8
Shale, red and gray	7	....	415	8
Sand shale	22	....	437	8
Shale, blue	46	....	483	8
Shale, blue	17	6	501	2
Coal	1	....	502	2
Fire clay	6	6	508	8
Shale, gray	10	...	518	8
Sandstone	6	....	524	8
Sand shale	7	....	531	8
Sandstone	17	....	548	8
Shale, blue	7	....	555	8
Shale, blue	3	....	558	8
Shale, black	1	3	559	11
Shale, gray	2	....	561	11
Shale, black	1	7	563	6
Coal (No. 7?)	4	4	567	10
Fire clay	3	9	571	7
Sandstone	3	....	574	7
Sand shale	6	...	580	7
Shale, blue	15	..	595	7
Shale, gray	4	....	599	7
Shale, bituminous	6	....	605	7
Carbondale—				
Coal (No. 6?)	....	9	606	4
Clay shale	3	3	609	7
Lime shale	6	....	615	7
Shale, blue	10	....	625	7
Sand shale	10	....	635	7
Sand shale	7	....	642	7
Shale, blue	22	9	665	4
Coal (No. 5?)	4	9	669	1
Shale, blue	....	9	669	10

Two deep drillings for oil have been put down in T. 20 N., R. 2. E. (Clinton Township), one in section 10 and the other in section 32. Both records are reproduced herewith, the record of the well in section

10 being copied from the Geological Survey of Illinois. Vol. 8, pages 34 and 35.

Record of drilling in sec. 10, T. 20 N, R. 2 E. (Clinton Township)
DeWitt County

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Surface soil	5	....	5	....
Quicksand	15	....	20	....
Sand with gravel and boulders	17	....	37	....
Sand and clay mixed	53	....	90	....
Hardpan	12	....	102	....
Gravel	1	....	103	....
Hardpan	4	....	107	....
Clay and sand	4	....	111	....
Gravel and clay	7	....	118	....
Hardpan	3	....	121	....
Clay and sand	7	....	128	....
Clay and gravel	14	....	142	....
Clay	4	....	146	....
Hardpan	6	....	152	....
Clay and gravel	8	....	160	....
Quicksand	5	....	165	....
Sand and gravel	2	....	167	....
Coarse gravel	2	....	169	....
Clay	6	....	175	....
Gravelly hardpan	25		200	
Quicksand	6		206	....
Sand and clay	7	....	213	
Gravel	9	....	222	....
Sand	11	....	233	....
Gravel	9		242	....
Sand	9	....	251	
Quicksand and gravel	101		352	
Pennsylvanian system—				
McLeansboro and Carbondale—				
Slate, black	1		353	
Fire clay	3		356	
Limestone (Lonsdale?)	19		375	
Fire clay	1		376	
Shale, gray	1		377	
Shale, red and gray	10		387	
Shale, gray	2		389	
Sandstone	36		425	
Shale, gray	32		457	
Shale, dark	6		463	

Record of drilling in sec. 10, T. 20 N, R. 2 E.—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Shale, gray	5	....	468	....
Coal (No. 7?)	2	9	470	9
Coal and "slate"	....	9	471	6
Fire clay	7	3	478	9
Limestone	22	....	500	9
Sandstone	6	....	506	9
Clay shale, gray	11	....	517	9
Sandstone	11	....	528	9
Shale, gray	8	....	536	9
Slate, black, and coal	3	....	539	9
Limestone	7	....	546	9
Sandstone	19	....	565	9
Shale, gray	10	....	575	9
"Slate," black	3	....	578	9
"Slate," black and coal	4	....	582	9
Shale, gray	21	....	603	9
"Slate," black	3	....	606	9
Coal (Worthen's No. 3)	1	....	607	9
"Slate," black and trace of coal	2	....	609	9
Clay shale, gray	3	....	612	9
Coal (No. 2?)	1	....	613	9
Pottsville—				
"Slate," black and trace of coal	3	....	616	9
Shale, gray	16	....	632	9
Limestone, hard impure	1	....	633	9
Sandstone, hard	3	....	636	9
Shale, gray	5	....	641	9
"Slate," black	8	....	649	9
Sandstone	10	....	659	9
Shale, gray	3	....	662	9
"Slate," black	2	....	664	9
Shale, gray	8	....	672	9
Shale, sandy	11	....	683	9
Shale, gray	9	....	692	9
Limestone, hard	1	....	693	9
Sandstone, hard	2	....	695	9
Shale, dark	3	....	698	9
Shale, gray	3	....	701	9
Shale, sandy	3	....	704	9
Sandstone	6	....	710	9
"Slate," black, with trace of coal	2	....	712	9
Shale, gray	82	....	792	9
Coal (No. 1?)	1	....	793	9
Shale, gray	10	....	803	9
Sandstone and shale	25	....	828	9

Record of C. C Morris' well near center sec 32, T. 20 N., R. 2 E., DeWitt County

Description of Strata	Thickness		Depth	
	Ft.	in.	Ft.	in.
Quaternary system—				
Pleistocene and Recent—				
Soil	5	...	5	....
Gravel	12	....	17	....
Quicksand	2	....	19	....
Clay and gravel, mixed	13	....	32	....
Clay and gravel, mixed	78	....	110	....
Clay and gravel, mixed	40	....	150	....
Quicksand	20	....	170	....
Hardpan	50	....	220	....
Quicksand	45	....	265	....
Pennsylvanian system—				
Limestone and "slate"	3	....	268	....
"Slate" rock, different color	8	...	276	....
Coal	5	...	281	....
"Slate," changing color	24	....	305	....
Sand	7	...	312	....
"Slate," first red found	12	..	324	....
Shell and "slate"	17	....	341	...
Limestone	7	....	348	..
"Casey oil-bearing strata"	10	..	358	..
"Slate"	19	...	377	..
Limestone, hard	2	...	379	...
"Slate" and coal	4	.	383	...
"Slate"	25	..	408	..
Coal (No. 7?)	6	...	414	
"Slate" of different color	49	...	463	.
Limestone	3	..	466	..
Sand	4		470	..
"Slate"	57	..	527	....
Coal (No. 5?)	2	..	529	....
"Slate," change color	33	...	562	....
Sand "slate"	15	....	577	...
"Slate"	90	..	667	...
Limestone	7	..	674	....
"Slate"	80	.	754	....
"Slate," sandy	12		766	
"Slate," black, no coal	18		784	.
Sand, limy	4		788	.
"Slate"	16		804	
Sand water	6		810	
"Slate"	19		829	
With oil scum	50	...	879	..
"Slate"	71		950	.
Mississippian system—				
"Marble, limy looking"	160		1110	
"Some strange formation"	40		1150	
"Slate"	40	.	1190	..
Shell	3	...	1193	....
"Slate"	7	8	1200	8

Worthen states that the drilling in section 10 was made with the diamond drill, and that it probably penetrated to the base of the "Coal Measures." He tentatively correlates the coal at 468 feet (2 feet 9 inches) with the upper vein (No. 7) in the Bloomington shaft, a record of which is given in the McLean County chapter; and regards the coals at 715 and 721 as possibly equivalent to No. 2 or No. 3, the latter coal not definitely recognized by the present Survey, and the coal at 903 as No. 1. These correlations seem to be consistent with the data assembled since the publication of Worthen's reports. Accordingly, a correlation of the upper coal at Clinton at 468 with the upper coal at Farmer City at 575 seems likely, especially as it is consistent with regional dip toward the trough at the foot of the west slope of the La Salle anticline. The actual difference in altitude may even be slightly more than is indicated by the difference in depth, as the surface altitude at Farmer City is less than at Clinton. It is possible that the limestone at a depth of 356 feet at Clinton is to be correlated with the Lonsdale. If so, the 114-foot interval between the limestone and No. 7 coal is only 25 to 30 feet greater than the usual interval to the north and west.

The log of the boring southwest of Clinton in section 32 is a churn-drill record, and the strata noted do not correspond closely with those reported to have been encountered in the drilling north of Clinton. However, the record is of interest in showing, probably accurately, the depth of the drift and the thickness of the Pennsylvanian; massive Mississippian limestone underlying the "Coal Measures" is entered at 950 feet, about 50 feet below the lower coal in the well north of Clinton. Accordingly it is probable that the well north of Clinton penetrated or nearly penetrated the Pennsylvanian strata at a depth of 942 feet, as suggested by Worthen. Correlations of the coal in the well in section 32 at 410 feet with No. 7 coal, and that at 527 feet with No. 5 is suggested.

STRUCTURE

DeWitt County lies near the center of the trough of the Illinois coal basin, the drilling at Farmer City possibly being approximately along the axis of the trough. It is believed that the strata dip gently eastward toward this trough, possibly at the rate of between 5 to 10 feet per mile. Data are insufficient to show whether or not there are important departures from the general dip. The eastward dip is also slightly modified by a still gentler southward dip of probably not over 5 feet per mile.

COALS

Three workable coals, No. 7, No. 5, and No. 2, possible underlie DeWitt County. The indications are that all the coals are thinner in the central part of the county in the vicinity of Clinton than to the east near Farmer City. The two upper coals are separated by 100 feet of strata and the two lower coals by about 150 to 175 feet of strata, consisting of sandstone and shale with some limestone. These intervals between coals No. 2, No. 5, and No. 7 persist directly northward into La Salle County and District I west of the La Salle anticline. To the northwest, west, and southward the intervals vary.

Further drilling is necessary in order to prove the presence or absence of considerable areas of workable coals in the county and the character of the roof and floor. No. 7 is reported to have a black shale cover at both Clinton and Farmer City, which is similar to conditions reported at Bloomington and farther north in the State. Blue shale is reported above No. 5 coal at Farmer City, and dark shale at Clinton. The coal is commonly capped by black shale elsewhere in the State.

It is possible that the coal resources of this county are large, but such data as are available do not encourage great expectation of large discoveries. Further careful prospecting is essential to a correct understanding of conditions.

FULTON COUNTY

PRODUCTION AND MINES

Production in tons, year ended June 30, 1920	2,331,975
Average annual production, 1916 to 1920	2,367,754
Total production, 1881 to 1920	47,178,407

Fulton County ranked twelfth in 1920, among the coal-producing counties, the output in that fiscal year being between 3 and 4 per cent of the total output of the State.

Table 6 lists the 27 shipping mines operating in 1920.

Besides the shipping mines 131 local or wagon mines also operated in 1920 with a total production of 150,320 tons. All the shipping mines in Fulton County with one exception operate No. 5 coal; the Spoon River Colliery Company, located at Ellisville, operates No. 1 or Rock Island coal. The local banks operate No. 1, No. 2, No. 5, and No. 6 coals, and a coal possibly correctly called No. 3.

SURFICIAL DEPOSITS

The thickness of glacial drift is known to be as much as 155 feet in one place, but the average of 293 wells in the area of the Canton and Avon quadrangles is only 38 feet. The drift consists of glacial stony clay or till with which is commonly associated one or two beds of gravel. Above those a mantle of yellow loess or silt 5 to 20 feet thick covers much of the upland surface, and deposits of alluvium lie in the valleys.

It has been determined from data concerning water wells between Put and Lost Grove creeks, that the drift is thick, so that the outcrop of No. 5 coal lies farther east than is the case south of Put Creek, and north of Lost Grove Creek. The position of this outcrop is indicated on the map, Plate V. This is the only pre-glacial drainage line that has yet been discovered in the county and it is probably the only one within the area underlain by No. 5 coal.

COAL-BEARING ROCKS.

The general succession of coal-bearing rocks in Fulton County has been indicated to some extent in Part I. It was there stated that because of special field examination in the area of the Avon and Canton quadrangles, which includes nearly all the north half of the county, and also because of the many exposures and coal prospects, knowledge of the coal-bearing rocks in this county is more definite than it is for the other counties in the district. However, as investigations and the commercial mining operations are restricted to the northern part of the county, conditions in the southern part can be less thoroughly described. It is believed that the southern part of the county, a large part of which is remote from a railroad, is probably not underlain by large bodies of the thicker and higher No. 5 and No. 6 coals, but that the lower coals may nevertheless be continuous. It is not improbable, however, that situated near the hill summits there are rather numerous small bodies of the thicker coal which may be suitable for stripping operations and local banks. The determinations of the actual amount of such coal require detailed field investigations which will probably be undertaken a little later. The present report concerns itself, therefore, chiefly with the area in the northeast part of the county underlain by No. 5 coal. The area to the west beyond the outcrop of this coal will receive more detailed description in the proposed report on District III in which coals No. 1 and No. 2 in the western part of the State from Rock Island to Alton will receive special attention. Drill records show that the base of the coal-bearing rocks declines eastward, so that these rocks are thickest in the eastern part of the county. In a deep well at Canton 465 feet of Pennsylvanian and overlying glacial material was penetrated; on the other hand, in the western part of the county near New Philadelphia, the base of the coal-bearing rocks is only 225 feet below the surface.

The youngest Pennsylvanian stratum exposed in the area is the Lonsdale limestone, which underlies the glacial drift in a small area in the northeast part of the county near Farmington. The special significance of this limestone in this study is the fact that its characteristic interval of about 60 feet above No. 7 coal furnishes a basis for the identification of this coal throughout Districts I and III. The limestone underlies a large area in Peoria County where it has been quarried to some extent. In this county No. 7 coal is too thin to be of commercial importance.

No. 6 coal is found outcropping in many places in the county between the outcrop of No. 5 coal and the area underlain by the Lonsdale limestone. It underlies an area of 35 to 40 square miles in the northeast part of the county, extending south from the north line to within two miles of Canton, and west as far as Fairview. It is also present in small areas northeast of Cuba. The approximate outcrop of this coal on the Canton and Avon quadrangles, as determined by Savage, is indicated on the structure map, Plate V. Like all the "Coal Measures" strata, it dips eastward at a low angle. No. 6 (Herrin) coal has in this region, as elsewhere, a limestone cap-rock 3½ to 4 feet thick, separated from the coal by 6 to 14 inches of bluish to dark calcareous shale. The cap-rock contains the fossil found in Illinois only in this stratum, namely, *Girtyina ventricosa*. Savage has identified twenty-two other fossils from this same bed in this county, but none has the value of *Girtyina ventricosa* in identifying the limestone.

The strata between the cap-rock of No. 6 coal and the Lonsdale limestone consist largely of shale. Savage states that overlying the cap-rock of the Herrin coal there is usually 10 to 15 feet of shale, followed by a few feet of sandstone, and which in turn is overlain by about 14 feet of gray and 18 inches of blue shale. No. 7 coal lies 33 to 36 feet above No. 6 coal. Above No. 7 coal is about 40 feet of gray shale, followed by 10 to 12 feet of dark shale which underlies the Lonsdale limestone. It is of some interest that the variegated shales near the horizon of No. 7 coal are found in the Peoria-Springfield areas and are widespread in District VII. They are not known, however, in all districts.

The interval between No. 6 and No. 5 coals varies somewhat in the county. In the northeastern part where the main body of the upper coal lies, the interval is normally about 65 feet. In Putnam Township, however, in the vicinity of Cuba, the interval decreases to such an extent that locally the two coals are thought to be in contact. They have been seen in outcrop within 7½ feet of each other, and one drilling in the vicinity of Cuba found 10 feet of coal. It is thought that this unusual thickness is probably due to lack of intervening strata between the two coal beds, No. 6 lying directly upon No. 5.

The strata between No. 5 and No. 6 consist of a black "slate" above No. 5 coal, 2 to 6 inches, above which is 9 to 20 inches of limestone cap-rock, 12 to 20 inches of soft gray shale or "clod," 20 to 30 feet of gray shale, a variable thickness of sandy shale and sandstone, 6 to 8 feet of yellowish shale, and 1 to 3 feet of the underclay of No. 6 coal. Between the 20- to 30-foot shale member, known as the Canton shale, and the sandy stratum overlying it, is an uneven plane of contact, which results in considerable variation in the thickness of both of these strata. In places, especially in Putnam Township, the Canton shale member is entirely out, so that the sandstone rests on the cap-rock of No. 5 coal or even locally upon the coal itself. Rarely all the strata normally occurring between the Springfield and Herrin coals are wanting, and more rarely a part or all of the No. 5 coal is absent.

The area in which No. 5 and No. 6 are actually in contact is small; and it is only in a small area lying mainly between the line of the Toledo, Peoria, and Western Railroad and Put Creek, in the north half of Putnam Township, that the nearness of No. 5 to No. 6 is especially noteworthy.

No. 5 coal is persistently present in that part of the county east of its line of outcrop. Numerous more or less detached areas of coal probably exist beneath the uplands along the main divides even south of Spoon River, since this coal has been mined at Astoria and in Schuyler County near Rushville. The outcrop of the coal within the Avon and Canton quadrangles is shown in Plate V.

Savage states that the No. 5 coal is uniform in thickness where it is found within the quadrangle, averaging 4 feet 8 inches in 141 well records and 43 measured sections, and generally departing less than 6 inches from the average. In the eastern and northern portions of the county, where the usual sequence of strata overlies this coal, the bed is commonly cut by numerous clay-filled fissures (clay seams or horsebacks), such as are characteristic of this coal in Sangamon County and in other parts of the State. Where sandstone overlies the coal in the vicinity of Cuba, no clay seams have developed. No. 5 coal is commonly correlated by its physical characteristics, especially the presence of horsebacks, and by the physical character of its roof. The black fissile shale containing ironstone or pyritic concretions, ranging from 3 to 4 inches to as many feet in diameter, is the very characteristic roof of the bed, a similar roof not being associated with the other coals. The clod and cap-rock are of local assistance in identifying the coal, but have not the State-wide distribution of the black "slate." The niggerheads, clod, and cap-rock are all fossiliferous, but as they lack definitely identifying forms, do not have the same value in correlation studies as the type fossil of the cap-rock of No. 6 coal. However, they are more or less characteristic.

Although coals below No. 5 are present in Fulton County within the area underlain by No. 5, they are worked only in areas west of the outcrop of this coal. There are two workable coals below No. 5, No. 1 (Rock Island) coal and No. 2 (Colchester or La Salle "Third Vein") coal. No. 2 coal has been worked at Avon; No. 1 is mined at Ellisville and has been worked recently at Seville; at local banks in the western and southern part of the county each of these coals is being worked.

Drilling in the northeastern part of the county, especially in Putnam and Buckheart townships, indicates the probable widespread presence of at least one of these lower coals.

No. 2 (Colchester) coal lies about 90 to 135 feet below No. 5, the lesser interval being found in the Cuba region, and the greater in the northeast part of the county. The strata between No. 5 and No. 2 consist mainly of shale and sandstone, a massive sandstone being rather widespread in the upper third of the section. The roof of No. 2 consists of gray shale or "soapstone" 9 to 14 feet in thickness in the northern and western parts of the county, but thicker toward the south. It is followed above by a black fissile shale 3 to 6 feet thick with which is commonly found a band of fossiliferous, septarian, nodular limestone one-half to one foot thick. Savage states that this is an easily recognized succession which is exposed in many places in the western part of the county. It is noteworthy also that essentially the same succession is found above No. 2 coal in the La Salle district west of the La Salle anticline and in much of District III to the west. The coal has a common thickness of about 2 feet 6 inches, but varies between 2 and 3 feet.

A coal believed to be the equivalent of the coal mined in Rock Island County and known as No. 1 or Rock Island coal, lies 60 to 90 feet below No. 2 coal, the interval being greatest to the east. The area in which this coal is best developed seems to lie west or south of the outcrop of No. 5 coal. The few drill holes to the base of the Pennsylvanian rocks east of the outcrop of No. 5 show coal thick enough to be of commercial value only at the horizon of the Rock Island coal in one or two cores, and these holes are located along the outcrop of the No. 5 coal in Putnam Township. The coal attains locally a thickness of about 4½ feet in the vicinity of Cuba, but there appears to be no large body of it and very commonly the seam is separated by shale partings. Where it is worked in the western part of the county at Ellisville, it is 3 to 5½ feet thick. This coal seems to have been laid down in a narrow trough or basin running north and south through the western part of the State, from Brown to Rock Island County, the eastern edge of which crossed the central part of Fulton County. Its area of main development is therefore west of this district in District III.

No. 1 coal where characteristically developed has a readily recognizable bluish, fossiliferous, limestone cap-rock 5 to 20 feet thick, which is separated from the coal by 6 inches to 3 feet of dark shale. In its typical development this cap-rock seems to be restricted to the same area as No. 1 coal, and to become thinner and possibly disappear entirely toward the east. The few drill holes in eastern Fulton County that penetrate No. 1 coal do not find a cap-rock above No. 1 coal.

No. 1 and No. 2 coals will be described in greater detail in a proposed later bulletin which will discuss the coal resources of District III.

Coals between No. 1 and No. 2 seem to be somewhat more numerous in the eastern part of the county than in the western. Between No. 1 and No. 2, lying 20 to 30 feet below No. 2, Savage reports a thin coal, 18 inches thick, which seems to be fairly persistent as it is found in outcrop in the western and central parts of the county and in drilling in the eastern part. Whereas this is the only persistent coal known in the section in the western part of the county where strata outcrop, drilling in the vicinity of Cuba, St. David, and Dunfermline reveals the presence of one or two other coals between No. 2 and No. 1. In the Cuba region the interval between No. 2 and No. 1 coals is about 80 feet. The following record of a hole drilled between Fiatt and Cuba is typical of the succession in that part of the county.

Record of drilling between Fiatt and Cuba See Plate II, No. 1

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Clay	18	....	18	....
Pennsylvanian system—				
Carbondale—				
Sandstone, yellow	10	4	28	4
Slate, dark	1	10	30	2
Coal (No. 5).	4	6	34	8
Shale, light	2	4	37	....
Sandstone, light	2	....	39	....
Shale, mixed	19	....	58	....
Sandstone, light	12	....	70	.. .
Shale, sandy	37	. .	107	. .
Shale, gray	20	....	127	
"Slate," dark	1	....	128	..
Rock (limestone?), dark	1	....	129	.. .
Shale, light	14	....	143	....
Coal (No. 2)	2	4	145	2
Pottsville—				
Shale, sandy, light	18	8	164	....
Coal	1	....	165	. .
Shale, light, sandy	12	...	177	. .
Shale, dark	1	.. .	178	. .
Coal	....	4	178	4

Record of drilling between Fiatt and Cuba—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Shale, light, sandy	18	....	196	4
Shale, dark	7	....	203	4
Coal	....	4	203	8
Sulphur (pyrite)	....	2	203	10
Coal	3	2	207	....
Sandy bottom	....	4	207	4
Rock, boulder (limestone?)	....	8	208	....
Limestone, dark	11	....	219	....
Shale, dark, hard	6	7	225	7
Coal (No. 1)	4	4	229	11
Shale, light, sandy	6	1	236	....

The lower coal with the dark limestone cap-rock is without question No. 1. In the Cuba region rather systematic testing of this coal in certain areas reveals large variations in thickness and character. Its commercial value, therefore, for the present, at least, is small. The limestone cap-rock is commonly about 10 feet in thickness but in places is absent and in other places as thick as 20 feet. The coal overlying the cap-rock or but a short distance above it, is lenticular. In a few holes it has a thickness of about 4 feet, but commonly is less than a foot thick, and so interbedded with shale that it has no value. It is not known just how persistent this bed is in the southern part of the county. It is possible that outcrops of this bed in the vicinity of Lewiston were confused with No. 2 coal by Worthen, resulting in the misinterpretation of the section that appears in his discussion of the geology of Fulton County in Volume IV of the Geological Survey of Illinois.

The two other coals that are fairly continuous in the section, one 12 to 20 or 25 feet below No. 2 coal, and the other about 30 feet lower, are generally thin. In some holes, however, the upper of the two is reported 2 feet or more thick, but it is more commonly found a foot or less in thickness. It is quite possible that this coal outcropping near Lewiston was the one which was confused with No. 2 coal instead of the lower coal as described in the preceding paragraph.

Aside from the limestone and coals noted above, the strata between No. 1 and No. 2 coals are mainly shale, with a sandstone 3 to 8 feet thick rather persistent 17 to 25 feet below No. 2.

STRUCTURE

Geologic structure of the whole of Fulton County has not been determined. A report on the structure based on the altitude of No. 2

coal in the Avon and Canton quadrangles appears in Bulletin 33,[1] and Plate V is a reduction of the maps in that report.

Concerning the structures of the Canton and Avon quadrangles, Savage[2] states:

"In the Colmar region farther west, the oil is found in the upper part of a dome, and in a terrace on its side. Even on this favorable structure, the sand is present only in limited areas. Consequently, any recommendations for test borings for oil in the Avon and Canton area, based on the usual structure features, must be recognized as carrying an unusual amount of uncertainty. However, since it is not possible to tell before borings are made whether the Hoing sand is present or to what extent it is saturated with water in any particular locality, if test borings are to be made, it would seem wise to proceed first on the usual assumption that the rocks will be thoroughly saturated with water, and to test first the places where the structure is favorable, as the highest parts of the anticlines and domes.

"From the structure maps [Plate V] it will be seen that a broad dome is present northwest of Fairview, the highest point of which is in the NE. ¼ sec. 29, and the SE. ¼ sec. 20, T. 8 N., R. 3 E. Southwest of Farmington in secs. 10 and 11, T. 8 N., R. 4 E., there is a low arch in which the beds are somewhat higher than to the north or south.

"From Fiatt a low arch extends toward the southeast corner of the Canton quadrangle. The axis passes about one-half mile north of Jones School, SW. cor. sec. 27, T. 7 N., R. 3 E., and has been traced southeast to the center of sec. 10, T. 6 N., R. 4 E.

"In the northwest quarter of the Avon quadrangle [Plate V], a low anticline is present in the SE. ¼ sec. 14, T. 8 N., R. 1 W. The beds here are somewhat higher than to the west, south, and east; but no outcrops are available toward the north, and the dip in that direction is uncertain. One mile north of Babylon in secs. 11 and the western part of 12, T. 7 N., R. 1 E., the beds are higher than in any other direction except northwest."

The foregoing interpretation of the structure in the Canton and Avon quadrangles was designed to meet inquiries concerning the possible existence of structure favoring oil and gas accumulation in the area. In general such gentle structure does not affect the value of the coal, although knowledge of the structure is of some importance in laying out mines in order to take advantage of the natural slopes for drainage or haulage. However, where regional structure is as gentle as it is here, local variation in the level of the coal may largely offset regional dip, and hence it becomes a distinctly local engineering problem to determine the structure or dip of the coal within each property to be developed. The present maps are of value in determining the general lay or dip of the bed and approximate depth, but should be used guardedly as a basis for laying out mining operations.

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[1] Savage, T. E., Geologic structure of Canton and Avon quadrangles: Illinois State Geological Survey Bull. 33, p. 91, 1917.

[2] Op. cit., p. 99.

On Plate V is included a structure map, which constitutes an appendix to Savage's maps and shows the "lay" of the No. 5 seam in a strip south of the Canton quadrangle, based on detailed drilling and elevation of the surface, as determined by the company. In publishing the map the Survey does not assume the responsibility for the accuracy of these determinations which in all cases do not seem to check closely with the topography on the Canton sheet. However, the map is valuable, especially as it illustrates the slight irregularities that affect the coal and shows how the eastward dip is in places eliminated or even reversed, and hence illustrates the importance of detailed drilling in the accurate determination of the structure prior to laying out properties for mining.

Minor irregularities in the coal beds encountered in mines will be discussed in later paragraphs.

MINABLE COALS OF EASTERN FULTON COUNTY

The coals of Fulton County known to have present economic value —that is, those that can be profitably worked at this time—are Nos. 6, 5, 2, and 1. Possibly a coal lying between Nos. 1 and 2 may also be workable locally. These coals will be described in the order given.

NO. 6 COAL

DISTRIBUTION AND OCCURRENCE

No. 6 (Herrin or "blue band") coal is present over about 35 to 40 square miles in the northeast part of the county, north of Canton, over a much smaller area north of Cuba. Other small areas not improbably exist, though they are not definitely known to be present. The outcrop of the coal on the Canton quadrangle is shown in the map, Plate V. The area underlain by coal has not been entirely delineated near Cuba. Savage states that the coal lies so near the surface, usually from a few to 50 feet, that its quality has been injured by the action of ground water so that even where it is present the shafts of the commercial mines are put down through this coal to the No. 5 (Springfield) bed which is normally about 65 feet lower.

CHARACTER OF NO. 6 COAL

No. 6 coal in Fulton County is not regarded with as much favor as is No. 5 coal. It is not always possible to tell from a physical examination of a coal bed why the coal is regarded as better or less satisfactory than the coal of an adjacent bed, as the differences are not entirely physical. The relative acceptability of different coals rests largely on the following factors: (1) The amount of ash; (2) the amount of volatile hydrocarbons; (3) the clinkering character of the ash, which is probably the same as the fusibility of the ash; (4) the hardness of the coal, or its ability to withstand handling; and (5) the heat value. For a certain class of users knowledge of the coking quality of the coal is also important. As the coal lies in the bed it is not possible to determine the relative value of the coal with respect to any of the above factors unless it be the amount of ash, and so it is only as a result of experience that judgment can be passed upon the acceptability of a coal.

In general judgment is made on the basis of results attained by the haphazard methods of firing in most steam plants and practically all domestic heaters. Since the fact that popular and careless methods may not be adapted to a coal in question commonly does not enter into the popular judgment, it is quite possible that with better practices in firing and improvements in heating systems coal at present less desirable would eventually come into more popular favor. It is also true that improvements in mining practice particularly in the method of handling the coal at the face, and at the tipple, may largely reduce the differences that exist among coals, especially as concerns the ash content.

The reasons for popular judgment against No. 6 coal and preference for No. 5 are not fully tangible. The general opinion is that this coal is dirtier; that it contains more shale bone, blackjack, and pyrite than No. 5; and that it is smokier, higher in volatile hydrocarbons, and probably somewhat softer, than the lower bed. Some of the prejudice against the upper coal arises from the fact that it lies relatively near the surface and is thought to have suffered somewhat from weathering. A considerable quantity is probably "outcrop" coal, which is usually soft and contains much infiltered clay. Outcrops of No. 6 west of Farmington are usually very poor, especially where the bed lies near the prairie surface, and the coal has a reputation of being generally unsuitable to mine. East of the line of the Chicago, Burlington and Quincy Railroad, between Farmington and Canton, however, along Copperas Creek, the cover is solid and the coal little affected by weathering, except for a few feet immediately along the outcrop. Failure to develop this coal in the shafts between Canton and Farmington is by some laid to the supposed ill effects of weathering, in spite of the fact that it is 50 to 60 feet down. It is possible, however, that the coal was affected somewhat by pre-glacial weathering, as the pre-glacial surface was much nearer the coal than is the present surface.

Where the coal has been observed in adjacent parts of Peoria County the only physical characteristic of the bed which suggests that it might have a value somewhat inferior to that of No. 5 is the rather high ash content, which is indicated by the presence of numerous sulphur balls and by the existence of a continuous blue band. Otherwise the coal does not appear notably different from No. 5 coal. It might justly be argued that the horsebacks of No. 5 coal represent a much more important source of impurities in that coal than do the sulphur balls and blue band in No. 6, so that the prejudice against No. 6 coal is probably based upon qualities not physically displayed in outcrop and at the face in mines.

Analyses and tests show very little difference between No. 5 and No. 6 coals in western Illinois, but whatever difference exists is to the advantage of the lower coal. The No. 6 coal averages about 4 per cent higher in volatile matter on the moisture-free basis, and possibly 2 to 4 per cent higher in moisture. Both coals, however, are relatively high in moisture, varying between 13 and 18 per cent, so that probably the difference in moisture content is of little consequence, and the difference in volatile content likewise hardly warrants favoring one coal more than the other on this score. It is possible, however, the higher coal yields its volatile matter at a lower temperature and hence is less desirable for general use. There is, however, no scientific basis for believing that a difference in the character of the volatile matter exists. Similarly also, whereas the ash of No. 6 coal may be considerably less refractory and hence harder to handle than the ash of No. 5 coal, this has not been scientifically established, and may or may not be a sound basis of difference. So much of the success in handling depends upon the adaptability of the furnace to the coal being used, upon the skill and experience of the fireman, and upon the method of firing that it is always a question until the matter has been authoritatively established, how much basis there is for popular discriminations as between different coals.

Physically No. 6 coal has the usual characteristics of the Illinois coals; namely, it is banded or laminated with alternations of dull and bright coal and occasional mother coal streaks. As a special characteristic of No. 6 coal, there exists a clay or "blue band" about a foot to 15 inches above the base of the bed. This is about 1 to 1½ inches thick and very persistent. Generally the coal is subdivided into three benches, the topmost of which is 12 to 15 inches. Between the top and middle bench is generally a mother coal parting. Commonly the coal has a dark shale roof that is hard to hold, for it generally falls up to the cap-rock, a distance of three feet or less, shortly after the coal is removed. The cap-rock is a 3- to 5-foot limestone, generally solid. The underclay is hard and 1 to 3 feet thick. The expense of moving the roof shale is a handicap against the profitable mining of this coal, although in general roof and floor conditions are not distinctly unfavorable.

NO. 5 COAL

The No. 5 or Springfield bed is the chief source of coal in the shipping mines in Fulton County. Except for a few local mines where No. 6 is worked, it is the only source of coal east of the No. 5 outcrop.

The general physical characteristics of No. 5 coal in Fulton County are similar to those elsewhere in the district, namely, regularity in thickness, common occurrence of clay slips or horsebacks, and a persistent black "slate" roof. Like all Illinois coals, No. 5 is well laminated or banded in structure, and contains lenses, streaks, or partings of mother coal, and occasional masses of bone coal. Balls and lenses of brassy pyrite occur in greater or less fequency, and not uncommonly the coal is "frozen" to the roof by a lens or layer of pyrite. The amount of pyrite varies considerably from mine to mine.

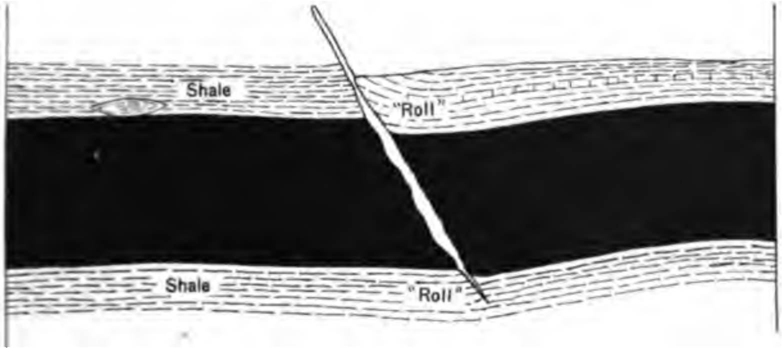

FIG. 5.—Diagrammatic sketch showing the relations of horsebacks to rolls in the roof and floor, and the accompanying faulting.

No physical characteristics peculiar to No. 5 coal in Fulton County distinguish it from the same coal elsewhere in the State. As in other parts of the district there is considerable irregularity in the distribution of the horsebacks, sulphur balls, and other features that detract from the value of the coal in the bed. A few mines in the county are so fortunately located as to be working a block of coal relatively free from impurities. Indeed, one mine reported that any payment to the miners for horsebacks, rolls, or boulders was the exception rather than the rule. In many other mines the extra pay for such irregularities is a serious item of expense. Necessarily this means a great difference in the profits for the various mines in the county. In 1917 the payment for horsebacks amounted to $2.84 for each horseback having an average thickness of 2 to 6 inches in the middle of the bed and 19 cents for each additional inch. In some mines the horsebacks are found as commonly as 12 to 15 feet; in other mines they are very unusual. No good reason has been arrived at for the erratic distribution of the horsebacks.

The horsebacks are usually accompanied by "rolls" in the roof and floor, which also must be paid for when removed. Those in the floor are usually removed, as they are thought to interfere with efficient shooting when left. Their removal is necessary to permit machine-mining. These rolls are apparently of two kinds: (1) In most instances, as in figure 5, faulting as well as fracturing has taken place at the horsebacks, and the coal, roof, and floor, has been offset from a few inches to as much as 18 to 24 inches in places. The upthrow side of the fault in the floor is called a roll in the floor, and the downthrow side of the fault in the roof is called a roll in the roof. In the case of low angle faulting the upthrow side of the floor is directly under the downthrow side of the roof, thereby reducing the apparent thickness of the coal in some places to 3 feet or less. In such instances the roof must be heightened to make head-room for the mules. (2) Rolls also may occur beneath horsebacks where the coal has not been faulted. They are commonly found under rather wide horsebacks and appear to be simply a bulge of the fire clay into the crack to a height of 6 to 12 inches. Rolls of the latter variety are usually small. Rolls are paid for by the inch per running yard.

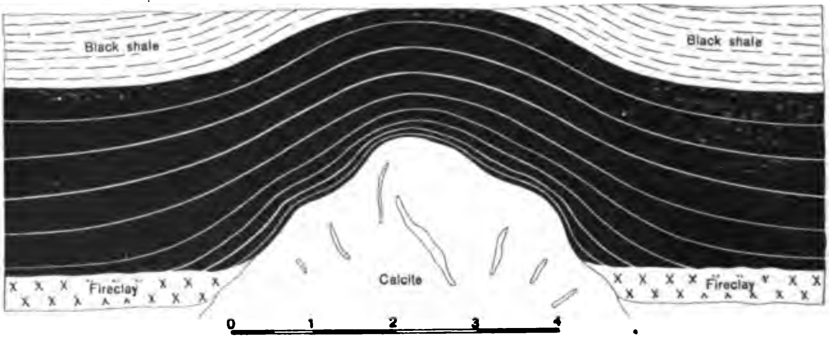

FIG. 6.—Limestone "boulder" in the floor of the Monmouth Coal Company's mine at Brereton.

An additional source of extra expense in some mines in the county consists of the floor "boulders" (fig. 6), which protrude from the fire clay into the bottom of the coal for a maximum distance of about 3 feet. They are commonly less than 2 feet in height in the coal, but may be nearly 3 feet thick, as has been stated, and extend laterally 4 to 5 feet. In 1917 the cost of their removal ran from $2.84 for those 18 to 24 inches high, down to $1.42 for those 6 to 12 inches high. No scale for large ones has been established, as they are uncommon. The boulders are masses of rather waxy-looking, silicified rock, part of a brownish color and part black. Both kinds seem to represent the silicification of woody material. These brownish parts show very distinct wood structure, and appear to be simply petrified. Material of the same character may be calcareous rather than siliceous. The black material, on the other hand, seems to represent silicified peat, or something of that nature, in which the unchanged carbon remains as a residue, making the rock black. The material has the appearance of a very carbonaceous quartzite. Such siliceous boulders are of course very hard and rather difficult to remove.

Some comment should be made upon the occurrence of the "spar" horsebacks that are found in this bed. These are as troublesome if not more troublesome than the clay slips, because they are harder along the immediate position of the fracture and the coal on each side of the fracture commonly contains a wider impregnation of pyrite. They consist merely of veins of pyrite in more or less vertical fractures, entirely resembling the horseback fractures except that they are not as wide and apparently do not extend to as great a distance vertically through the overlying rock. Rarely is the coal bed offset along such spar horsebacks.

The semi-monthly adjustment for horsebacks, rolls, and boulders is an ever-present source of bickerings and misunderstandings between miners and foremen, because of the difficulty in the interpretation of the rules of the agreement. It is exceedingly difficult to ascertain a fair average value for the thickness of a horseback or to accurately measure the size of a roll, especially as the adjustment is usually made after the roll and horseback has been removed from the room or entry and the measurement is made on the cross-section appearing on the rib. A more satisfactory adjustment of this labor problem will obviate much of the difficulty in mining the coal.

Where the coal is undisturbed by irregularities, conditions are relatively favorable for mining. The underclay is hard and generally thin and does not creep readily, so that it rarely causes trouble because of squeezes. The overlying black shale is usually hard and stands well without much timbering after the removal of the coal. Certain difficulties are encountered, however. The niggerheads in the shale, which are occasionally large enough to interfere with operation if left up in a roadway, are heavy and rather difficult to handle. Occasionally one of those left in the roof will loosen and fall. Therefore, to some extent they are a source of possible injury to miner or mule. In some of the mines near Farmington the lower 2 to 3 inches of the "slate" called "draw slate" separates from the main body of the "slate" at what is known as a "false parting" as the coal is removed. When this happens the coal is usually "frozen" to the "draw slate," so that in discarding the "slate" considerable coal, frequently as much as 6 to 8 inches, is thrown into the gob. The "freezing" of coal and "draw slate" is apparently due to a layer of pyrite or pyritized limestone in the top of the coal, the presence of which makes it very difficult to separate the coal from the shale. In one mine where this "draw slate" exists it is reported that its removal is not desired, as the overlying shale is rather difficult to hold. A more desirable condition is to have the coal break away from the roof just below the top of the seam, leaving the sulphur streak in the roof.

In the mines south of Canton and more or less throughout the county, the most serious difficulty arises from the tendency of the "draw slate" to come away with the coal. As long as this lower layer of the shale stays up and the air is kept away from the overlying shale, the roof will remain solid, but once it falls the conditions are almost immediately bad, the shale and overlying clod falling up to the cap-rock. In places even the cap-rock lacks coherence to withstand the strain put upon it when the "slate" falls and the resulting holes in the roof of the mine are expensive to handle.

In one or two mines west of Farmington, a fairly persistent thin "mud seam" occupies a position in the bed about 8 inches below the top. It was reported that in one mine there were several rooms in which the coal had been shot off below this mud seam. It was stated that unless the miner exercises care in placing his holes so that they end above this mud seam, the coal tends to break below it. A similar mud seam lies about 18 inches from the floor in this same mine, and similar care must be taken that the powder holes be driven below the band to insure complete removal of the bed. These bands are not persistent but are very common.

In some of the mines southwest of Canton lying in the bottom of the coal is a band of blackjack, 1 to 3 inches thick, which shoots up with the coal and must all be handled and thrown into the gob. As separation from the coal is not clean, considerable coal is in this way wasted. The blackjack consists of soft carbonaceous shale and coal containing lenses of pyrite up to about 1 inch in thickness and making up about one-fourth of the mass.

MINE NOTES, NO. 5 COAL

ALDEN COAL COMPANY'S MINE NO. 5, AT FARMINGTON

Entrance: Shaft; depth to No. 5 coal, 185 feet.

Thickness of coal: Varies from 3 feet 9 inches to 4 feet 2 inches; averages 4 feet.

Section of the coal:

	Thickness					
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof: Black "slate"						
Coal	3	1½	4	3½	2	1
Sulphur	..	½	..	..	..	1
Coal	..	9¾	..	..	1	10
Floor: Fire Clay	..	..	..	..	..	..
	3	11¾	4	3½	4	0

Character of the coal: The coal is comparatively clean as compared with the same bed in Peoria County. The horsebacks are fairly numerous but rather narrow, commonly not over 4 inches through. About as common as the clay slips are the "spar'' horsebacks which are hard and contain crystalline pyrite that fills the crack and ramifies into the coal for several inches on each side, producing a belt of hard coal often nearly 8 inches to a foot wide, through the center of which runs the vertical irregular fissure. "Facings" of pyrite in the joint cracks of the coal are not uncommon. Gypsum or pyrite facings are not common. Clay and mother-coal streaks are rarely more than half an inch thick and are neither continuous, nor especially numerous.

Pyrite in balls or niggerheads is not uncommon. This is pure shiny pyrite apparently of good quality, averaging probably at least 45 per cent sulphur for the hand-cleaned specimen. The masses of pyrite are said to attain a thickness of about 12 inches and to extend for a distance of 5 to 6 feet. None of this size were seen, the largest noted being about 6 inches thick with a lateral extension of possibly 3 to 4 feet. The rooms do not commonly have more than one sulphur ball in the face at one time, averaging possibly 1½ inches thick and 2 inches in diameter. The amount of pyrite actually seen in the face is probably less than 0.5 per cent by weight of the coal.

Character of the roof: The roof is very regular. It consists of the usual succession of black "slate" with niggerheads 8 to 14 inches thick, clod 6 to 8 inches thick, and cap-rock 4 to 8 inches thick. The niggerheads are commonly about 18 inches in diameter, though some are of still larger size. They parallel the bedding of the "slate" and are nearly as thick from top to bottom as is the "slate." These protrude down into the coal and are frequently slick on the surface and lie more or less loosely in the shale, so that they generally drop out. Many are considerably pyritized, some of the smaller ones completely so, but the larger ones for a distance of only about half an inch from the surface. The change from the calcareous center to the pyritic outer layer seems to be direct and not gradual. Ordinarily, however, there is more or less pyrite all through the boulders with an increase in amount toward the pyritic shell.

The lower 2 to 6 inches of the black shale or "slate" is known as the "draw slate." Between it and the overlying shale is what is known as a false parting, along which the two beds separate in places in the mine. More often there is a good parting between the coal and the "draw slate," and the latter does not come away. Where the coal and "draw slate'' stick together, a lens of fossiliferous limestone, for the most part highly pyritized, in most cases lies just at the top of the coal. The limits of pyritization are rather indefinite, extending outward into both the coal and "slate," so as to cause the adherence of the whole mass and the fall of the "draw slate" with the coal when the latter is shot.

Character of the floor: The floor clay in this mine, about which there is nothing unusual, is reported to be about 2 feet thick on the average. It apparently does not heave much. Along entries it is the practice to remove about 10 inches of the floor clay to make headway for the mules.

ALDEN COAL COMPANY'S MINE NO. 6, AT NORRIS

Entrance: Shaft, depth 190 feet to No. 5 coal.

Sections of the coal:

Sections of No 5 coal in the Alden Coal Company's No. 6 mine

	Face entry main west 1900 feet from shaft		2d north off east entry 1200 feet from shaft		Entry face main east 2000 feet from shaft	
	Ft.	*in.*	*Ft.*	*in.*	*Ft*	*in.*
Coal, dull	..	7	..	..	..	4
Coal bright	1	8	4	1	3	8
Coal, dull	..	¼	..	..	..	..
Coal, bright	1	10	..	..	..	..
	4	1¼	4	1	4	0

ASTORIA WOODLAND COAL COMPANY'S ABANDONED MINE

Entrance: Shaft; depth to coal, 58 feet.

Thickness of the coal: Varies from 5 feet to 6¼ feet; averages 5½ feet.

Section of the coal:

Section of No. 5 coal in the NE. entry about 1700 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal	2	1
Black jack	..	1
Coal	1	..
Mother coal	..	¼
Coal	1	10
Sulphur	..	¼
Coal	..	11
Floor: Fire clay	..	..
	5	11½

The top coal is dark and often broken. At the top of the uppermost of the two 1-foot coals there is commonly a very dark-colored hard cannel-like coal 2 to 3 inches thick. The lowermost of these two coals is soft, and has irregular streaks of sulphur. The bottom bench is a very bright, hard coal. The roof is black shale, more than 3 feet thick, with large nigger-heads or balls of iron pyrite. The floor is fire clay, at least 3 feet thick. The irregularities include large clay veins, some displacing the coal 18 inches. These veins which are exceptionally large, commonly cut entirely through the coal and are as much as 12 feet long and 3 to 4 feet wide.

This property was abandoned in 1910.

BIG CREEK COAL COMPANY'S MINE NO 2, AT ST. DAVID

Entrance: Drift; No. 5 coal.

Thickness of coal: Varies from 4 feet 10 inches to 5 feet 2 inches; averages 5 feet.

Sections of the coal:

Sections 3 to 8 are taken from United States Bureau of Mines Bull. 22, p. 495.

Sections of No. 5 coal in the Big Creek Coal Company's No. 2 (St. David) mine

	(1) 2,200 feet N. W. of drift mouth		(2) 2,500 feet west of drift mouth	
	Thickness			
	Ft.	*in.*	*Ft*	*in.*
Coal	2	..	3	½
Sulphur	..	⅛	..	¼
Coal	..	6	1	7¼
Blackjack	..	⅛	..	..
Shale	..	..	..	2
Coal	1	10¼	..	..
Blackjack	..	1	..	..
Shale	..	2¼	..	..
	4	4½	4	8¼

	(3) Room 3 18th E. 6000 ft. from opening		(4) Entry face 7th W. 4500 ft. from opening		(5) Entry face 15th N. 6000 ft. from opening		(6) Entry face 11th N. 6000 ft. from opening		(7) Entry face 7th E. 5000 ft. from opening		(8) Entry face 14th E. 5500 ft. from opening	
	Thickness											
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal, dull	1	2	1	..	..	8	..	..	..	..	..	9
Sulphur	..	⅛	..	..	..	..	..	..	..	..	..	..
Coal, bright	3	7	4	3	4	..	2	1	4	4	..	..
Coal, dull	..	..	..	..	..	..	..	4	..	..	..	..
Mother coal	..	..	..	..	..	..	..	..	..	..	..	¼
Coal, bright	..	..	..	..	..	..	2	8	..	..	1	11
Sulphur	..	..	..	..	..	..	..	..	..	..	..	⅛
Coal, bright	..	..	..	..	..	..	..	..	..	..	1	10
Total	4	9⅛	5	3	4	8	5	1	4	4	4	6⅜

Character of the coal: The coal bed is uniform throughout, without persistent benches. Small pyrite bands and streaks of mother coal are present. Some gypsum is reported in the facings. At the time the mine was examined in the summer of 1912 the number of horsebacks in the working face was reported as relatively small. In 1908 an earlier observer reported a large number in the mine, which indicates that the coal probably varies considerably as regards frequency of the horsebacks.

Character of the roof: The roof consists of a "draw slate," composed of fine-banded, sandy shale, more or less impregnated with pyrite, 1 to 2 inches thick, black "slate" 2 to 4 feet thick, and a limestone cap-rock. The cap-rock, which is notably persistent, varies in thickness from 6 to 18 inches, but is commonly about 10 inches thick. Its distance above the coal varies from 1 to 4 feet, but is, for the most part, 2 to 2½ feet. The "draw slate" noted above is not a typical "draw slate" as it is usually left up. It probably has about the same characteristics as the "draw slate" observed in mine No. 4 of this company.

Character of the floor: The floor is a hard, bluish-gray clay, 2 feet 6 inches in average thickness. This clay is undercut by mining machines. It heaves somewhat after standing 18 months to two years.

BIG CREEK COAL COMPANY'S MINE NO. 4, AT DUNFERMLINE

Entrance: Shaft; depth to No. 5 coal about 82 feet.

Thickness of coal: Varies from 4½ feet to 5⅓ feet; averages 5 feet 8 inches.

Character of the coal: The coal is very similar to that southwest of Canton. The bed is fairly massive, but to some extent tends to shoot off in benches due to the presence of rather conspicuous but not entirely persistent "dirt" or charcoal bands. Commonly four thin dirt bands lie about 8, 14, 24, and 30 inches from the top, respectively. The coal has distinct horizontal partings and tends to shoot up rather fine. The considerable quantity of mother coal present makes the coal sooty and dirty to handle. A blackjack or clay band about 1½ inches thick is practically continuous. It does not contain the gray sulphur found in the Middleton and Eagle mines near Canton.

Horsebacks are present in about the usual number, but are apparently thinner than they are farther north, so that as a whole they constitute a somewhat less serious difficulty. Pyrite is present in the coal as balls of clean pyrite and to less extent as lenses of grayish laminated pyrite. The balls are most commonly 2½ to 3 inches thick and 8 to 14 inches in diameter, and weigh 20 to 30 pounds. The largest ones, however, may weigh as much as 200 pounds. It is estimated that about one ton of pyrite a day or about one-tenth of one per cent of the total coal mined is uncovered in the coal.

Character of the roof: Roof conditions are similar to those generally found in the mines south and southwest of Canton. The interval between the cap-rock and the coal increases to the south and the cap-rock is somewhat thicker than it is north of Canton. It is more difficult to distinguish the stratum called "draw slate" from the black shale above, as neither does it contain the whitish limy concretions found in the mines farther north, nor are the limestone lenses present which in the mines north of Canton are so commonly found at the top of the coal and the base of the "slate." The parting between coal and "slate" is better than to the north so that the coal breaks away, leaving the "slate" undisturbed. Where the "draw slate" falls, conditions are almost immediately bad, for the black shale and clod (the upper part of the shale) have very little coherence. Over many of the entries the cap-rock is exposed the intervening shale having fallen in. It is higher above the coal than is commonly the case north of Canton, generally being 4 to 5 feet. In places the cap-rock is thin, especially where its lower surface is smooth instead of knobby, as is more frequently the case. The special problem in the mine seems to be that of holding the thin layer of "draw slate'' in the rooms. The main haulageways are commonly brushed up to the cap-rock. The expense of this dead work of course is to be avoided if possible in the rooms.

Character of the floor: When machines are used the coal is cut just above the blackjack band in the base of the coal. In solid shooting the entire bed shoots out and the blackjack must then be cleaned off the coal. The underclay is about 2 feet thick. The floor rolls, as a rule, under the horsebacks.

CANTON COAL MINING COMPANY'S NO. 1 MINE (ABANDONED), SOUTH OF CANTON

Entrance: Shaft; depth to No. 5 coal about 55 feet.

Thickness of the coal: Reported to average 5 feet in thickness.

Section of the coal: In room No. 1 off the third southwest entry the coal was 53 inches thick, and had 2 inches of bone or blackjack at the base. The coal is probably similar to that elsewhere south and southwest of Canton.

EAGLE MINING COMPANY'S MINE AT CANTON

Entrance: Shaft; depth to No. 5 coal 103 feet.

Thickness of the coal: Varies from 4 to 5½ feet; averages 4 feet 11 inches.

Sections of the coal:

Section measured in the Eagle Mine near Canton
1000 feet north-northeast of shaft; face of 4th east entry off the main north entry

	Thickness Ft.	in.
Slate	..	10
Coal	4	7½
Dirt band	..	1½
Fire clay	2+	..

Character of the coal: The coal in this mine is representative of the seam south of Canton. It differs from that to the north in being more slabby. Three fairly persistent soot or clay partings, which may vary in position as much as an inch or two each way, lie about 8, 14, and 22 inches from the top, respectively. Commonly a sulphur parting is found

22 to 24 inches from the bottom or about 35 inches from the top, which in places enlarges to become a bright sulphur ball 3 to 6 inches thick. Sulphur lenses and balls are also present here and there in the bed, but are found most frequently in the middle of the bed or up near the roof, and adjacent to horsebacks. In the bottom of the coal is a band of fire clay, coal, and sulphur, 1 to 3 inches thick, called blackjack, which shoots up with the coal and must be cleaned by the miner. The pyrite in the blackjack is of a gray banded variety similar to the brown sulphur found in some of the mines in the Peoria district.

Horsebacks are rather frequent, occurring probably about every twenty feet, but are generally less than 4 inches thick. As elsewhere they are separated from the coal that is loaded out, and a large per cent of the discarded mass is good coal. The waste represented by their removal makes up a considerable but not definitely known per cent of the bed.

Character of the roof: The roof of the seam is the usual black "slate" and clod. The black "slate" is about 10 inches and the clod 14 inches thick. The "draw slate," which is commonly 2 to 3 inches thick and contains numerous small scattered lenses of whitish limestone not larger than ¼ inch by 1 inch, usually stays up. In places an inch or so of the coal stays up in the roof with the "slate," but in other places the coal is separated from the "slate" by a smooth parting. The shale contains a good many niggerheads which tend to fall out, bringing more or less of the shale with them and thereby weakening the roof. When the "draw slate'' comes down and the air gets to the black "slate" and clod, they also generally fall. The cap-rock may or may not be strong enough to hold after the shale has fallen. Roof conditions in this mine are not especially satisfactory; room occasionally have to be abandoned on account of the poor roof conditions.

Character of the floor: The floor consists of the ordinary fire clay and ordinary floor conditions prevail.

EAST CUBA COAL MINING COMPANY'S LOCAL MINE NO. 1 (ABANDONED), AT CUBA

Entrance: Shaft; about 71 feet to No. 5 coal.

Thickness of the coal: Varies from 4 feet 8 inches to 5 feet 4 inches; averages 5 feet.

Sections of the coal:

Section in the mine of the East Cuba Coal Mining Company
Room 1, off 2d east off 1st south off west

	Thickness	
	Ft.	*in.*
Coal	1	11½
Sulphur	..	¼
Coal	..	8¾
Sulphur	..	⅛
Coal	2	..
Sulphur	..	½
Coal	..	1½
Fire clay	4	10½

Character of the coal: Except for the lower 1½ to 2 inches of the coal, which is blackjack, the coal is bright, black, and hard.

Character of the roof: The roof is a black shale 2½ feet thick overlain by six inches of clod or soft gray shale, followed by the cap-rock, which is about 2½ feet thick.

Character of the floor: The floor is gray clay.

Irregularities: The continuity of the bed is broken by what is described as an old stream channel, probably a buried pre-glacial or glacial line of drainage along which the coal has been removed.

MAPLEWOOD COAL COMPANY'S MINE NO. 1, AT FARMINGTON

Entrance: Shaft; about 122 feet to No. 5 coal.

Thickness of coal: Varies from 3 feet 10 inches to 5 feet; averages 4 feet 2 inches.

Character of the coal: The coal is noted as black, shiny, long grain, and uniform from top to bottom. The horsebacks or clay veins are commonly 3 to 6 inches thick, but exceptionally 3 to 4 feet. The smaller veins are the harder.

Character of the roof: The roof consists of 4 inches of black "draw slate," about 24 inches of black shale, and about 10 inches of limestone cap-rock. Above the cap-rock is 15 feet more or less of light sandy shale.

Character of the floor: The floor consists of fire clay 20 inches thick, resting upon a 1-foot limestone layer.

MAPLEWOOD COLLIERY COMPANY'S MINE NO. 2, AT FARMINGTON

Entrance: Shaft; about 146 feet to the top of No. 5 coal.

Thickness of coal: Varies from 3½ to 4 feet; averages 3 feet 9 inches.

Sections of the coal:

Sections in mine No. 2, Maplewood Colliery Company
Section 1—Third south off third west entry

	Thickness	
	Ft.	*in.*
Roof; shale, black, sheety, with niggerheads	..	..
Shale, black, draw	..	4
Coal	4	..
	4	4

Section 2—Face of room 1 off 5th west off north entry, 4,000 feet from shaft

	Thickness	
	Ft.	*in.*
Coal, dull	..	9
Coal, bright	2	11
	3	8

Section 3—Entry rib in the 2d west off main north entry, 3,500 feet from shaft

	Thickness	
	Ft.	*in.*
Coal, dull	1	..
Blackjack	..	¼
Coal, dull	..	9
Blackjack	..	¼
Coal, bright	..	10
Pyrite	..	⅛
Coal, bright	..	4½
Coal, bony	..	½
Coal, bright	..	2
Coal, bony	..	¾
Coal, bright	..	10
	4	1⅜

Character of the coal: The coal has no special peculiarities. It is without benches and conspicuous bedded irregularities. The most persistent banded irregularity is a thin layer of blackjack and pyrite 6 to 8 inches above the base of the coal. The coal is commonly "frozen" to the roof shale, so that it does not come away very evenly.

Character of the roof: The roof consists of 4 to 6 inches of carbonaceous shale or "draw slate," 18 to 30 inches of black shale, and 12 to 18 inches of limestone cap-rock.

Section of the roof of mine No. 2, Maplewood Colliery Company, 700 *feet east of the shaft on the main east entry*

	Thickness	
	Ft.	*in.*
Shale, carbonaceous, rather soft, with ironstone concretions, about	6	..
Cap-rock; a dark gray limestone with irregular fracture. Bottom of limestone very uneven	1	3
Clod; a black sheety shale with fossil shells	1	2
"Slate;" black, hard, sheety shale with bands of ironstone nodules. Lower 4 inches filled with bands of ironstone, limestone, and pyrite nodules	1	3
Coal	..	..

MONMOUTH COAL COMPANY'S MINE NO. 1, AT NORRIS

Entrance: Shaft; about 142 feet to No. 5 coal.

Thickness of coal: Varies from 4 feet to 4 feet 8 inches; averages 4 feet 4 inches.

Sections of the coal:

Sections of coal in No. 1 mine of Monmouth Coal Company

	(1) Entry face 1st E. off S. (16th N.) 4200 ft. from shaft.		(2) 23d W. off main south 4500 ft. from shaft.		(3) Entry face 15th S. off 1st west north side 4500 feet from shaft	
	Thicknesses					
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal	4	2	..	..	..	..
Coal, dull	..	..	..	..	..	7
Coal, bright	..	..	2	9	3	9
Sulphur	..	..	..	⅛	..	..
Coal, bright	..	..	1	8	..	..
	4	2	4	5⅛	4	4

Character of the coal: The coal is uniform throughout in general appearance, and does not lie in benches. Streaks of pyrite and mother coal are not uncommon, but for the most part the coal is laminated, bright, and blocky, and is typical for Illinois. The greatest difficulty consists of the horsebacks which average 1 to 2 inches in width and which often contain considerable pyrite.

Character of the roof: The immediate roof is 18 inches to 2 feet of black shale called "slate," with a gritty limestone cap-rock about 6 inches thick.

Character of the floor: The floor is fire clay 1 to 1½ feet thick, containing boulders and nodules of pyrite. The boulders in the clay are reported by one observer to be septarian in character, that is, crossed by cracks and containing cavities lined with calcite. The coal is reported to ride over the boulders as shown in the accompanying reproduction of a sketch (fig. 6) made in the northeast part of the mine. The boulders are especially numerous on the north side of the shaft and are also found in the mines at Norris.

STAR COAL COMPANY'S MINE NO. 1, AT FIATT

Entrance: Shaft; depth of No. 5 coal about 56 feet.

Thickness of coal: Varies from 4½ to 5 feet; averages 4 feet 8 inches.

Sections of the coal:

Sections of the coal in mine No. 1 of the Star Coal Company

Section 1—Room face, room 39 off 15th south, off main east

	Thickness	
	Ft.	*in.*
Roof: Black sheety shale containing niggerheads	..	..
Coal: Rather dull and hard with irregular rather than banded appearance. A few vertical irregular veinlets of pyrite, and a little calcite in facings is present and mother coal in slight amount in thickness up to about ¼ inch	4	7
Floor: Fire clay, soft, dark gray; heaves badly in air as well as in water; considerable pyrite in upper two inches	..	..

Sections 2 to 4

	(2) Entry face 20th south 4500 ft. from opening		(3) Entry face 15th south 3500 ft. from opening		(4) Entry face 16th 4000 ft. from opening	
	Thicknesses					
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Coal, dull	..	10	..	..	..	..
Coal, bright	..	..	4	4	4	3
Mother coal	..	¼	..	..	..	..
Coal, bright	..	6	..	..	..	..
Mother coal	..	½	..	..	..	..
Coal bright	2	..	..	..	..	..
Mother coal	..	½	..	..	..	..
Coal, bright	1	2	..	..	..	..
	4	9	4	4	4	3

Character of the coal: The coal is not subdivided into benches. It is fairly hard, dull in appearance and has hackly fracture and laminated structure. A little pyrite is ordinarily interbedded about 18 inches from the top. There are no clay slips.

Character of the roof: The immediate roof is black "slate" 6 to 20 inches thick, above which is a micaceous sandstone 2 feet or less in thickness. The lower 2 inches of the "slate," called the sulphur band, is crowded with fossils largely pyritized.

Section of roof of No. 5 coal, mine No. 1, of the Star Coal Company, at Fiatt

Section 1—1800 feet from opening on the main east entry

Sandstone.

Soapstone, unconformable in relation to strata below; in places cuts out cap-rock.

Cap-rock; a fine-grained, calcareous and micaceous sandstone, carrying carbonaceous material; thickness up to 6 inches.

Clod; a dark brownish-gray shale with many shells—3 inches.

"Slate;" a black sheety shale, 1 foot 6 inches.

Coal.

Section 2—2500 feet from portal on main east entry

	Thickness	
	Ft.	*in.*
Soapstone; dark gray sandy shale, irregularly bedded, about	4	..
Cap-rock and clod	few	inches
"Slate;" hard black sheety shale	1	3
Shale; sheety, hard, with pyrite	..	4
Coal	..	..

STAR COAL COMPANY'S MINE NO. 3, AT CUBA

Entrance: Shaft; 26 feet to No. 5 coal.

Thickness of coal: Averages 4 feet 8 inches.

Section of the coal:

Section of the coal in mine No. 3 of the Star Coal Company
(Measured in temporary north entry)

	Thickness	
	Ft.	*in.*
Coal	1	9
Parting	..	..
Coal	..	8
"Soot" seam	..	..
Coal	1	8
	4	1

Character of the coal: At the section given above, the coal was uniform in appearance, hard, and rather tough. A narrow vertical sulphur streak lay in the upper part of the bed. Horsebacks are not numerous.

Character of the roof: The roof consists of 2½ feet of black "slate" above which is the cap-rock, about 12 to 18 inches thick.

Character of the floor: The floor consists of fire clay.

MIDDLETON COAL COMPANY'S MIDDLETON MINE, AT CANTON

Entrance: Shaft; 60 feet to the top of No. 5 coal.

Thickness of coal: Varies from 4½ to 5 feet; averages 4 feet 9 inches.

Character of the coal: The coal is separated into poorly distinguished benches by thin clay and mother coal partings, one about 8 inches from the top and another about 1 foot lower. The partings are fairly persistent and the tendency of the coal to break along them must be considered in placing the shots, in order that all the seam may be loosened. A blackjack seam 1 to 3 inches thick at the bottom of the bed is an important impurity. It is composed largely of soft carbonaceous shale and coal with lenses of pyrite up to about 1 inch in thickness making up about one-fourth of the mass. It commonly shoots up with the coal and must be separated by the miner. Considerable coal is wasted in this way. This material makes up the greater part of the gob.

Pyrite is present in the coal as balls of hard, bright "sulphur" and in the blackjack band in a grayer, more earthy form. Sulphur balls were observed at the face of about two-thirds of the rooms and entries visited. They are commonly 2½ by 10 or 12 inches, but in rare cases are 6 inches thick and 3 feet across. A few horsebacks cut the coal, occurring possibly every 50 to 75 feet, but they are not especially troublesome.

Character of the roof: Roof conditions in this mine are somewhat different from those in the mines north of Canton. The "draw slate" is not well differentiated. The coal more commonly breaks smoothly away from the "slate" so that over much of the mine a smooth clean roof is present. In places, however, the coal is "frozen" to the "slate," and coal and slate come away together. This weakens the roof so that eventually it falls even through the cap-rock. Above the cap-rock is a layer of weak clay shale which is called clod, but which is not to be confused with the clod between the black "slate" and cap-rock. Above the upper clod is a gray soapstone. As the shales above the cap-rock carry considerable water, water enters where falls occur.

Character of the floor: The floor is fire clay.

SILVER CREEK COLLIERY COMPANY'S NO. 1 MINE, AT FARMINGTON

Entrance: Shaft; 41 feet to the top of No. 5 coal.

Thickness of coal: Varies from 3 feet to 4 feet 2 inches; averages 4 feet.

Character of the coal: The coal does not lie in benches but contains a few discontinuous thin partings ⅛ to ¼ inch thick, and an occasional nodule of clean, brassy pyrite. Clay and "spar" horsebacks are rather numerous; the removal of this material necessitates extra expense and results in considerable waste. That the amount of bright brassy-looking pyrite is small is indicated by the fact that out of 17 rooms visited, two had one nodule each in the face. One of these was 4 to 6 inches thick and 12 to 15 inches in length, and the other 3 to 4 inches thick and 18 inches across. The amount of pyrite present is rather below the average for the mines of the county.

The peculiar hard masses, called boulders, at the base of the coal, consist of masses of hard brownish rock with a porous texture. Certain of these boulders have the appearance of coke. The material seems to be silicified or calcified wood or peat, as certain fragments show very clearly the wood structure. The character of the replacing mineral varies, some boulders being part silica and part calcite. Further investigation is necessary in order to determine the exact nature of this impurity. One of these boulders measured 14 inches high by about 2 feet across but they vary greatly in size.

Character of the roof: The roof succession, which is similar to that in the other mines of the Farmington region, consists of the "draw slate," "slate," and cap-rock. The behavior of the "draw slate" is uncertain. In places the coal parts freely from the "slate" and the latter stays up, so that slightly less head room is left than is necessary for the mules, and along considerable stretches of the entries about 10 inches of fire clay must be dug up. Commonly, however, the coal sticks to the "draw slate" because a band of pyrite or limestone at the junction of the two strata "freezes" the coal to the "slate." Under these circumstances the "draw slate" comes down with the coal, a condition which is desired even though the coal must then be cleaned off by the miner.

Character of the floor: The floor is fire clay. The layer is about 6 inches in thickness and squeezes up into the entries somewhat where they are wet.

NATIONAL COAL MINING COMPANY'S MINE, WEST OF FARMINGTON

Entrance: Shaft; 105 feet to the top of No. 5 coal.

Thickness of coal: Varies from 3 to 4 feet; averages 3 feet 10 inches.

Character of the coal: The rooms and entries of only the north and west sides were visited. The property adjoins that operated by the Silver Creek Colliery Company on the east and it is probable that conditions in the adjacent parts of the two mines are similar.

At the face the coal displays a slight tendency toward benching. Two "mud" bands a quarter of an inch or less in thickness are commonly present, one about 8 inches from the top and another about 18 inches from the bottom. These are not persistent in the Farmington district, and even in the National mine, are not continuous; but they are reported in at least one other mine. Their presence makes it necessary for the miner to drill his holes so that they end above the upper seam and below the lower; otherwise the middle bench will break away from the upper and lower portions of the bed.

Impurities other than the clay bands noted in the preceding paragraph are not common. Horsebacks of either the clay or "spar" variety seem to be somewhat less common than in most of the mines in the county. The amount of pyrite present in balls and lenses is small. Although no boulders in the bottom of the coal were observed, their occurrence in the adjoining Silver Creek mine would indicate that they may be found or at least expected occasionally in the National mine.

Character of the roof: Roof conditions in general are excellent. The succession is similar to that in other mines in the vicinity, namely, "draw slate," about 3 inches; "slate," 8 to 14 inches, averaging about 10 inches; "clod," about 10 inches; and cap-rock, about 18 inches. In some places pre-glacial erosion channels have cut down nearly to the coal, so that the rock above the seam is only 15 to 20 feet thick. Under such places the roof tends to be weak, so that the rooms cave and let in water. Such falls are the principal difficulty encountered in the mine.

Character of the floor: The floor is fire clay 12 to 18 inches thick and has hard rock below it. The clay heaves but little if any.

GENUINE NORRIS COAL MINING COMPANY'S MINE NO. 1, AT NORRIS

Entrance: Shaft; 180 feet to the top of No. 5 coal.

Thickness of the coal: Varies from 3 feet 9 inches to 4 feet 2 inches; averages 4 feet.

Character of the coal: The coal is without benches, and contains a few streaks of clay and mother coal one-eighth inch or less in thickness, none of them regular, and here and there a pyrite nodule 2 to 3 inches by 6 to 8 inches. These latter are not common. The horsebacks occur in about the usual frequency and size. The impurity most difficult to handle consists of the floor boulders. These are masses of very hard brownish to black rock occupying the lower part of the bed. Some are nearly 3 feet thick and extend laterally 4 to 5 feet. They are similar to the boulders noticed in the mine of the Silver Creek Colliery Company and apparently consist of areas of silicification. Pyrite is present in only relatively small amount as spar sulphur and balls. It is an impurity of little consequence in this mine.

Character of the roof: The usual roof conditions for this area exist. The "draw slate" is persistent. Best mining practice in this mine requires that the "draw slate" remain up, for considerable difficulty is experienced in holding the black "slate" and clod after the "draw slate" falls. The cap-rock seems to be fairly good, but is crossed here and there by incipient cracks which widen on exposure to the air, thereby loosening the rock.

At one locality in the mine along the main south entry, above the black "slate," a massive sandy rock is present which appears to be a very sandy phase of the cap-rock. The sandstone "rolls" down through the clod so that it rests upon the black "slate" within 14 inches of the coal. At this place the coal also dips rather sharply beneath the roll. This is the only structural irregularity, other than the clay or spar slips, that has been noted in the county.

The "draw slate" is a limy black "slate" containing small lenticular bodies of calcareous sandstone or sandy limestone about ⅛ inch thick and 1 inch in diameter. In places it becomes very calcareous and contains lenses of limestone composed of shells which are commonly pyritiferous. The niggerheads seem to be of different origin. They are apparently concretionary and generally not fossiliferous. They seem to be embedded mainly in the black shale or "slate" and to extend down into the "draw slate" or even into the coal.

Character of the floor: The floor is described as fire clay and is said to be about 2 feet thick.

SIMMONS COAL COMPANY'S MINE, AT CANTON

Entrance: Shaft; 121 feet to the top of No. 5 coal.

Thickness of the coal: Varies from 4 to 4½ feet; averages 4 feet 4 inches.

Character of the coal: The coal face was not observed in this mine. The coal is reported to be cut by fewer horsebacks than usual for this area, and the quantity of pyrite is also small. Some bright pyrite in balls is present, however. No boulders in the floor are reported.

The coal bed is interrupted both to the north and south by "faults." They appear to be deposits of sand and gravel made in pre-glacial channels, the floors of which were below the level of the coal.

Character of the roof: The roof is of the usual character. There is generally about 3 inches of "draw slate" present, black "slate" with clod above, about 18 inches thick in all, and the ordinary limestone cap-rock 4 to 10 inches thick.

CRIPPLE CREEK COAL COMPANY'S MINES AT BRYANT

Entrance: Drift; No. 5 coal.

Thickness of the coal: Varies from 4 feet 6 inches to 5 feet 2 inches; averages 4 feet 8 inches.

Character of the coal: The coal lies in benches due to three thin "soot" or mother-coal bands, 8, 22, and 31 inches from the top of the bed respectively. Horsebacks are present but are thin, rarely being more than 2 to 3 inches across. Rolls in the floor are usually less than 6 inches in height. In most of the rooms the coal breaks smoothly ½ to 1 inch below the "slate," leaving a fairly even top, a condition which is rather uncommon for this area. Niggerheads generally work loose and fall out and then the rest of the roof up to the cap-rock falls down. Pyrite is not common.

Character of the roof: The general succession above the coal is the same as in other mines in the area. The black shale and clod above the coal varies in thickness from 3 to 5 feet and the limestone cap-rock is 4 inches or more thick.

COAL BEDS BELOW NO. 5 COAL

In Fulton County the two coals which represent the largest resource are beds No. 2 and No. 1. The former seems to be widespread east of its outcrop. It is thin, but in many records of drilling it varies between 2 feet 6 inches and 3 feet, so that very probably there are large areas that could be profitably mined later if not now. Fortunately the need for the exploitation of such bodies of coal does not exist. No. 2 coal has the usual soapstone or gray shale roof commonly found over this coal in northern Illinois, with a 3-foot bed of black sheety shale at various intervals above the coal, up to possibly about 20 feet. The roof is such as to favor the longwall system of extraction, which is practically always employed where the coal is mined. The bed is usually fairly free from impurities and the coal of somewhat better quality than the coal in the higher beds in the same region.

The lower coal, No. 1 (Rock Island) bed has a much more erratic distribution than have the upper beds. It seems to be fairly persistent, but varies greatly in thickness and is commonly interrupted by lenses of shale which would render it unminable. It is not impossible, although the possibility is gradually being lessened by drilling, that there are areas of sufficient size to be of importance in which No. 1 coal attains a continuous thickness of more than 4 feet. Its normal development, however, is in lenticular bodies, the exploration and outlining of which is expensive, so that it will not be generally undertaken for many years. Furthermore, the roof conditions of this coal are irregular and result in high mining costs. Where it is present close to the coal the limestone cap-rock makes an excellent roof; but too commonly there is a mass of rather loose shale between the coal and the limestone which under present practice must usually be moved. The irregular character of this coal makes possible the discovery of small areas from which large returns can be expected, but for the most part No. 1 probably is not as important a resource as No. 2 coal.

Intermediate thin coals between No. 2 and No. 1, each generally less than a foot thick, locally thicken so as to be workable. Sometime there will no doubt be an eager search for workable areas of these coals, but at present they seem to have no commercial importance.

KNOX COUNTY

PRODUCTION AND MINES

Production in tons year ending June 30, 1920	34,753
Average annual production, 1916-1920	29,387
Total production, 1881-1920	1,866,061

The production of coal from Knox County in 1920 was entirely from wagon or local mines, about three-fourths from No. 6 coal, about one-fourth from No. 5, and a small amount from another bed possibly No. 1. The statistics of labor tabulate 27 mines, of which more than half are drift and slope mines. The county ranked thirty-ninth among the fifty-three producers.

Members of the present Survey have visited only four operations in the county and none of these is now in operation. The outcrop and structure of the various coals have never been determined, and for general geological conditions reliance is placed chiefly upon the report by Worthen in the Geological Survey of Illinois, Vol. IV, pp. 313 to 324. His account of the coals underlying the county is unfortunately confusing because of the wrong identification of at least one and possibly other coals, and because of general uncertainty as to correlation.

Knox and Fulton counties occupy a corresponding position across the outcropping edges of the commercial beds of the State. All the beds of commercial importance except No. 7 and possibly No. 1 outcrop within the county in more or less parallel belts extending north and south. No. 6 lies near the east line and what is possibly No. 1 near the west line. The coal of greatest importance in quantity is probably No. 5. No. 2 probably underlies the largest area, whereas No. 6 is limited to a small area in the eastern part of the county, bounded by its line of outcrop on the west, and No. 1 is limited as a commercial coal in its distribution by its decrease in thickness to the east.

SURFICIAL DEPOSITS

A factor which greatly hinders the development of the considerable amount of outcrop coal in the county is the covering of glacial drift.

The glacial drift is generally but 20 to 30 feet in depth, but in places where valleys have been filled, the depth may reach 100 feet or more.[1]

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[1] Leverett, Frank, Illinois Glacial Lobe: U. S. Geological Survey Mon. 38, p. 676, 1898.

The upper part of the drift is composed of fine yellowish silt or loess, which is somewhat more widespread than the glacial clay or till and is especially effective in concealing outcrops.

The position of the pre-glacial channels which cross the county has not been determined.

COAL-BEARING ROCKS

It is believed that in general the succession of coal-bearing rocks in Knox County is the same as in Fulton County eastward, and the coals outcrop in more or less parallel belts extending north and south. No. 6 coal underlies the higher parts of the county south and east of Spoon River, with No. 5 coal outcropping at lower levels. North of Spoon River, No. 6 coal is present on the uplands in the north half of the county as far west as Wataga, Oneida, and possibly Knoxville, but it is probably not generally present south of the Santa Fe Railroad. The area wherein No. 5 coal lies nearest the surface has not been well defined, due to some extent to the confusion in the correlation of this coal. Coal which is described by Worthen[1] as No. 4 is probably No. 5, just as is the case in Fulton County. Other coals, such as that mined at Soperville, which have been called No. 5, are still lacking definite correlation but appear to lie below No. 5 coal. No. 2 coal seems to be the coal nearest the surface in the western part of the county along the Chicago, Burlington and Quincy Railroad, running south from Galesburg through Abingdon and St. Augustine. There are many outcrops of this coal along Spoon River and its tributaries at relatively low altitudes in the county. It is also exposed at a few places near the western edge of the county north of Galesburg. No. 1 coal is possibly of workable thickness along Spoon River valley near the south line of the county, since it is being worked but a short distance south in Fulton County at Ellisville. However, as elsewhere in the State the distribution of this coal is irregular; whether it is generally present in workable thickness is doubtful.

For the general succession in the county we are dependent upon a few records of scattered drilling, the most of which are located in Henderson Township. Other holes have been drilled in Lynn, Galesburg, Copley, Persifer, and Knox townships.

The succession in Henderson Township is illustrated by the following drill records:

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[1] Geological Survey of Illinois, Vol. IV, pp. 313-324.

Record of drilling on the farm of J. Snodgrass in the SW. ¼ NE. ¼ sec. 10, T. 12 N., R. 1 E., Knox County, Illinois.

Estimated elevation about 800 feet above sea level.

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Clay, sandy	20	....	20	....
Pennsylvanian system—				
Shale, gray	33	....	53	....
"Slate", dark	2	1	55	1
Coal	1	2	56	3
Shale, gray	2	7	58	10
Sandstone, light	3	2	62	....
Shale, light	2	2	64	2
Sandstone, light	1	4	65	6
Shale, light	15	3	80	9
"Boulder" (limestone?), light	2	2	82	11
Shale, gray	8	1	91	....
Shale, sandy brown	30	....	120	....
Sandstone, gray	15	4	135	4
Shale, dark	7	11	143	3
Limestone, blue, very hard	2	....	145	3
Shale, dark	7	9	153	....
"Slate," dark	1	11	154	11
Coal	1	7	156	6
Coal, impure (No. 1?)	....	2	156	8
Coal	....	4	157	....
Fire clay	2	....	159	....
Sandstone, white	8	10	167	10
Shale, sandy, light	4	10	172	8
Shale, sandy, gray	7	8	180	4
Shale, sandy, light	5	8	186	....
Coal, soft	1	....	187	....
Shale, sandy, light	2	2	189	2
Shale, lime	4	4	193	6
Sandstone, light	3	10	197	4
Shale, sandy, light	1	4	198	8
Sandstone, light, very hard	4	2	202	10
Shale, sandy, light	7	6	210	4
Shale, gray	2	7	212	11
Coal	1	2	214	1
Shale, gray, sandy	5	11	220	....
Sandstone, gray	....	6	220	5
Shale, dark	1	8	222	2
"Cap rock" (limestone?), very hard	1	1	223	3
Coal, impure	2	4	225	7
Sandstone, gray, hard	....	10	226	5

Record of drilling on the farm of J. Snodgrass—Concluded

Description of Strata	Thickness		Depth	
	Ft.	in.	Ft.	in.
Sandstone, light, hard	3	3	229	8
Shale, sandy, light	7	4	237	....
Shale, sandy, gray	10	3	247	3
Coal	....	11	248	2
Shale, gray	3	6	251	8
Shale, light gray	4	....	255	8
Shale, sandy, gray	8	1	263	9
Coal	....	3	264	....
Fire clay	1	4	265	4
Shale, sandy, gray	4	1	269	5
Coal	....	2	269	7
Shale, sandy, light	....	10	270	5
Sandstone, light, hard	2	8	273	1
"Slate," dark	10	6	283	7
Sandstone, light, very hard	1	6	285	1
Shale, dark	36	....	321	1
"Slate," dark, hard	15	10	336	11
Sandstone, light, hard	2	6	339	5

Record of a drilling on the H. Smith farm in the SE. ¼ SW. ¼ sec. 16, T. 12 N., R. 1 E., Knox County, Illinois.

Estimated elevation about 750 feet above sea level.

Description of Strata	Thickness		Depth	
	Ft.	in.	Ft.	in.
Quaternary system—				
Pleistocene and Recent—				
Clay	26	....	26	....
Sand, gray	35	4	61	4
Sand and gravel	5	....	66	4
Pennsylvanian system—				
Shale, dark	....	6	66	10
Coal	3	1	69	11
Shale, light	6	9	76	8
Coal	....	2	76	10
Shale, sandy, brown	6	2	83	....
Sandstone, dark	7	....	90	....
Sandstone, light	25	....	115	....
Shale, gray, light	3	2	118	2
Shale, dark	8	6	126	8
"Cap-rock" (limestone?)	2	....	128	8
Shale, dark	7	2	135	10
Shale, bituminous	2	3	138	1
Shale, light gray	1	6	139	7
Coal, (No. 1?).	2	3	141	10
"False bottom".	....	4	142	2
Fire clay	1	10	144	....

The identification of the coals in the foregoing records is not definite. The nine holes drilled in the vicinity of Henderson are alike in showing a coal at a depth of 125 to 150 feet which is apparently the coal found at 154 feet 11 inches in the drilling on the Snodgrass farm and at 139 feet 9 inches in the drilling on the Smith farm. The presence of a hard blue limestone cap-rock a few feet above this coal suggests its correlation with No. 1 coal of Mercer and Rock Island counties. It is thought that this same bed is worked at Soperville by T. H. Milan and Company, where the coal is 100 feet below the surface. In this shaft the cap-rock (or "bed-rock," as it is called) is about 8 feet above the coal. The seam is from 2 to 4½ feet thick, with an average thickness of about 4 feet. If this is No. 1 coal, then the stratigraphic succession in northwestern Knox County varies from that farther south in that the Pottsville formation is thicker and the Carbondale formation probably thinner to the south and southeast.

It is believed that the coal underlying Henderson Township is certainly below the horizon of No. 5, and accordingly that this part of the county, as well as Rio, Galesburg, Cedar, Indian Point, Orange, and Chestnut townships forms part of District III, in which coals No. 1 and No. 2 are the principal coals mined. They will accordingly be included in the District III report. It is believed that with a small amount of additional field work the correlation of the coals in this part of the county can be satisfactorily settled.

The coals lying below No. 1 or the Soperville coal as shown in the record of the drilling on the Snodgrass farm are not commonly present in Illinois, except possibly in adjacent parts of Henry, Mercer, and Rock Island counties. Except in these counties 200 feet or more of Pottsville is unusual in the northern part of the State. It is possible that locally some of these lower coals may be of workable thickness, but they are not known to be worked in Knox County.

The succession in Galesburg Township is known only from the logs of churn-drill holes for water made by the city. Although these records are of little service in determining the character of the strata, they indicate, however, that the base of the Pennsylvanian strata is at a depth of about 330 feet below the surface at well No. 3. Of this thickness about 80 feet is drift and the remainder probably Pottsville. At Knoxville, in Knox Township, the base of the Pennsylvanian is possibly at a depth of 480 feet, as indicated by the deep water well record.

The following record is that of a diamond-drill hole near Etherly in Copley Township, the exact location of which is not known:

Record of drilling for the Etherly Coal Company, near Etherly, T. 12 N., R. 3 E., Knox County, Illinois.

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Clay, yellow	33	....	33	....
Pennsylvanian system—				
McLeansboro—				
Sandstone	9	....	42	....
Shale, light	3	....	45	....
"Soapstone"	16	....	61	....
Limestone, blue	1	3	62	3
Clay	....	6	62	9
Carbondale—				
Coal (No. 6)	4	2	66	11
Clay	....	6	67	5
"Slate"	7	7	78	....
Limestone	5	....	83	....
"Soapstone"	14	....	97	....
Shale, dark	30	....	127	....
Shale, black	18	....	145	....
"Slate"	6	4	151	4
Coal	....	11	152	3
"Slate" (No. 5 coal?)	2	....	154	3
Coal	....	8	154	11
Shale, light	12	1	167	....
Clay	5	....	172	....
Shale, light	34	....	206	....
Limestone	2	....	208	....
Shale, dark	14	....	222	....
Clay, fine	8	....	230	....
"Soapstone," black	17	....	247	....
Limestone	1	....	248	....
"Soapstone," black	2	....	250	....
Limestone	....	4	250	4
"Slate"	5	8	256	....
Clay	....	9	256	9
Coal (No. 2)	3	6	260	3
Pottsville—				
Clay	1	8	261	11
Limestone	....	3	262	2

Of the coals listed above, it is probable that the one at 62 feet 9 inches is No. 6 coal and the one at 256 feet 9 inches, No. 2. No. 5 coal does not seem to be present, though it may be represented by the thin coals at 151 feet 4 inches, and 154 feet 3 inches. The interval between No. 2 and No. 6 in this drilling, namely, 190 feet, is about the same as it is in Fulton County.

A boring near Dahinda in Persifer Township penetrated strata to a depth of 220 feet, beginning apparently about 30 feet above the level of No. 2 coal. No coal was encountered below No. 2. The record is reproduced below.

Record of a boring near Dahinda, Knox County, on the Sargent farm
Drilled 1914

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Clay, sandy	6	....	6	....
Sand and gravel	3	6	9	6
Sand, gray	13	....	22	6
Sand	1	6	24	....
Pennsylvanian system—				
Carbondale?—				
Coal, soft drift	2	8	26	8
Shale, light	3	5	30	1
Coal (No. 2?)	2	9	32	10
Pottsville?—				
Fire clay	2	....	34	10
Sandstone, light	11	7	46	5
Shale, sandy, light gray	14	....	60	5
Shale, light	4	10	65	3
Sandstone, gray	57	8	122	11
Sandstone, light	10	6	133	5
Sandstone, gray	11	....	144	5
Shale, sandy, gray	1	4	145	9
Shale, dark	1	2	147	11
Fire clay	....	9	148	8
Shale, dark	2	1	149	9
Fire clay	4	10	154	7
Shale, sandy, gray	11	2	165	9
Shale, dark	2	....	167	9
Limestone, dark	13	....	180	9
"Slate," dark	1	4	182	1
Shale, light sandy	3	6	185	7
Sandstone, light	4	....	189	7
Sandstone, hard, white	7	2	196	9
Shale, gray	11	2	207	11
Shale, light, sandy	8	....	215	11
Sandstone, light	3	6	219	5
Shale, light, sandy	1	4	220	9

A boring in the extreme northeast corner of the county shows a total thickness of about 420 feet of drift and Pennsylvanian strata. If the record can be relied on, the stratigraphic succession in the locality seems to differ considerably from that in the southern part of the county. Although there is little basis for the correlation of any of the coals, a tentative correlation is suggested in the record which follows:

Record of coal prospect in sec. 1, T. 13 N., R. 4 E , Knox County

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Clay, gravel and sand	36	....	36	....
Pennsylvanian system—				
McLeansboro—				
Sandstone, gray	9	....	45	....
"Slate," gray	9	....	54	....
"Slate," dark	42	....	96	....
"Slate," dark, gritty	4	....	100	....
Carbondale—				
Coal (No. 6)	....	4	100	4
Fire clay, blue	2	9	103	1
"Slate," light	2	....	105	1
Sand rock, gray	5	....	110	1
"Slate," light	4	....	114	1
Sand and rock, gray	5	....	119	1
"Slate," light	3	....	122	1
"Slate," gritty, gray	43	....	165	1
"Slate," dark	20	....	185	1
"Slate," mild black	22	8	207	9
"Slate," gritty, blue	4	....	211	9
"Slate," gray	3	9	215	6
Coal (No. 5)	2	6	218	....
Fire clay, light	2	11	220	11
"Slate," gray	5	....	225	11
"Slate," dark	2	....	227	11
Shale, light	11	....	238	11
Sand rock, gray	3	....	241	11
"Slate," light	8	....	249	11
Sand rock, gray	12	....	261	11
"Slate," dark	1	8	263	7
Coal (No. 4)	1	10	265	5
Sand rock, gray	2	6	267	11
"Slate," dark	6	5	274	4
Coal (No. 3)	....	7	274	11
Fire clay, light	3	....	277	11
"Slate," dark	10	....	287	11
"Slate," black	2	....	289	11
"Slate," light	11	....	300	11
"Slate," dark	16	6	317	5
Coal (No. 2)	1	1	318	6

Record of coal prospect in sec. 1, T. 13 N., R. 4 E., Knox County—Concluded

Description of Strata	Thickness		Depth	
Pottsville—	*Ft.*	*in.*	*Ft.*	*in.*
Fire clay, light	1	5	319	11
"Slate," light	3	....	322	11
Sand rock, light	10	....	332	11
"Slate," dark	12	....	344	11
Coal (No. 1)	....	11	345	10
Fire clay, dark blue	4	1	349	11
Shale, light	3	....	352	11
Rock, hard, gritty, white	4	4	357	3
Lime shale, blue	12	8	369	11

The foregoing represents the information available concerning coal in Knox County, aside from that found in Volume IV of the Geological Survey of Illinois, which may be briefly summerized as follows:

"No. 6 coal is found principally in the eastern half of the county. It varies in thickness from 4 to 6 feet and has a blue band 1½ to 2 feet from the floor. The coal has been worked probably entirely by wagon mines, in T. 13 N., R. 2 E., sec. 36; in T. 12 N., R. 4. E., secs. 4, 5, 17, 18, 19, 29, 30, 31 and 32; in T. 12 N., R. 3 E., secs. 1, 10, 11, 18, 19 and 20; in T. 12 N., R. 2 E., secs. 12, 13, 15, 22, 23 and 24; in T. 11 N., R. 3 E., secs. 3, 4 and 5; in T. 10 N., R. 4 E., sec. 15; in T. 9 N., R. 4 E., secs. 23, 24, 31, and probably 32 and 33; and in T. 9 N., R. 3 E., in sec. 35. The coal has a limestone cap-rock which in places is 4 feet thick.

"The coal is only found in the higher portions of the county, which are principally in the eastern half, and north of Spoon River in the western half of Victoria Township, T. 12 N., R. 4 E., and northwest part of T. 12 N., R. 3 E., Copley Township, and east part of Sparta, T. 12 N., R. 2 E."

No. 5 coal (Worthen No. 4?) lies 40 to 60 feet below No. 6 and commonly varies between 3 and 4 feet in thickness. Mines have been operated in this coal in sec. 25, T. 12 N., R. 4 E., and in secs. 2 and 3, T. 13 N., R. 1 E., possibly along Sugar Creek in T. 12 N., R. 3 E., secs. 9, 16, 32, and along Middle Creek in T. 11 N., R. 2 E., and sec. 25, T. 11 N., R. 1 E., sec. 3, T. 9 N., R. 4 E., and secs. 26 and 27, T. 10 N., R. 4 E.

This coal underlies more of the county than does No. 6; it is probably present in T. 13 N., Rs. 2, 3, and 4 E., and the eastern part of R. 1 E.

No. 2 coal is generally from 1½ to 3 feet thick and of good quality in comparison with other coals in the county. It has been worked in secs. 20, 21, 29, 30, 32, and 33, in T. 12 N., R. 1 E.; in secs. 16 and 23, T. 11 N., R. 2 E.; in secs. 13, 19, 22, 23, and 35, T. 11 N.,

R. 3 E.; at various places in Truro Township, T. 11 N., R. 4 E., along Spoon River; in secs. 8, 16, 19, 29, T. 10 N., R. 3 E.; in secs. 14, 22, 23, 25, 26, 27, 29, 33, 34, T. 10 N., R. 2 E. These operations are by drifting or stripping. There were no shafts to No. 2 when Worthen's report was written in 1870.

No. 1 coal (Worthen correlation) was worked in one place in sec. 21, T. 12 N., R. 1 E., where it is 6 feet thick. It was worked by a shaft 30 feet deep. This is probably the same bed now worked at Soperville.

Mine Notes

Detailed information about the mines in Knox County is very meager. Four mines have been visited by members of the Survey, none of which is now in operation.

The following data are available concerning these operations:

MINE OF ALBERT WALBURG, KNOXVILLE

Wagon mine.

Entrance: Shaft, 45 feet in depth. Coal mined is probably No. 5. The coal is cut by numerous vertical clay "veins" which pass into the coal, some from the floor and others from the roof. A section of the bed is measured about 300 feet southwest of shaft, as follows:

Section of coal at Walburg mine

	Thickness		Thickness of coal	
	Ft.	*in.*	*Ft.*	*in.*
Roof: Shale, black	2	..		
Sulphur	..	2		
Coal	1	10	2	5
Sulphur	..	½		
Coal	..	6½		
Floor: Fire clay	..	1		

JOHN D. YOUNG MINE, NEAR ABINGDON

Drift mine, operating No. 2 coal, with an average thickness of 2 feet, but varies from 20 to 26 inches. The coal is bright, hard, with brownish streaks. It breaks into cubical pieces, with a conchoidal fracture. Sulphur occurs in irregular lenses at various places in the bed. The following section was measured about 100 feet southeast of entrance:

Section of coal at Young mine

	Thickness		Thickness of coal	
	Ft.	*in.*	*Ft.*	*in.*
Roof: Shale gray	6	..	..	..
Coal	1	3	1	11¾
Sulphur	..	¾		
Coal	..	8		
Floor: Fire clay	8	..	..	..

The roof is fine gray shale, falling in layers 2 to 4 inches thick. It has a thickness of 6 feet or more. The floor is a shale or fire clay at least 3 feet thick.

MINE OF PENDERGAST BROS., AT SOPERVILLE

Entrance: Shaft 120 feet deep, to No. 1 coal. The record of the shaft is as follows:

Record of Pendergast shaft

	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Drift	10	..	10	..
"Soapstone," gray	85	..	95	..
"Slate"	2	6	97	6
Coal	1	10	99	4
Shale, blue	7	..	106	4
Limestone, white, flinty	1	2	107	6
Limestone, bluish	7	..	114	6
Coal (No. 1)	5	..	119	6

This is apparently No. 1 coal of Mercer and Rock Island counties. Another coal, about 40 feet lower, outcrops in places along the creek. The coal was measured in 2d room north, on the east side of shaft about 75 feet east and 100 feet north of opening.

Section of coal in Pendergast mine

	Thickness		Thickness of coal	
	Ft.	*in.*	*Ft.*	*in.*
Roof: Limestone	7	..		
Coal	..	7	3	5⅞
Black jack	..	2		
Coal	2	..		
Sulphur	..	⅜		
Coal	..	8½		
Floor: Fire clay	4	..		

MINE OF GALVA MINING CO., NEAR WATAGA

Shaft mine, 68 feet 6 inches to the floor. Coal averages 4 feet in thickness, varying from 3 feet 4 inches to 4 feet 2 inches. The cap-rock is black to gray shale, 1½ to 4 feet, with a limestone cap-rock 3 feet or more thick. The coal was measured at the 2d north entry about 450 feet from the shaft.

Section of coal in Galva mine

	Thickness		Thickness of coal	
	Ft.	*in.*	*Ft.*	*in.*
Roof: Gray to black shale	1	6+		
Coal	1	2	2	10½
Sulphur and soft shale	..	½		
Coal	..	10		
Shale, soft (blue band?)	22	2		
Coal	..	8		

LOGAN COUNTY

PRODUCTION AND MINES

Production in tons year ending June 3, 1920	2,263,222
Average annual production 1916-1920	452,644
Total production, 1881-1920	10,130,415

Logan County produced a little more than ½ of 1 per cent of the total output for Illinois during the year ending June 30, 1920, and ranked twenty-third in the State. Two mines, both at Lincoln, are now being operated in this county, one by the Latham Lincoln Coal and Mining Company, and the other by the Citizens Coal Mining Company. Table 6 is a list of the shipping mines and data concerning them.

SURFICIAL DEPOSITS

The rock succession in Logan County is known only as it is shown by the records of three drill holes and of three shafts. The drill holes are located at Atlanta and near Lincoln and the shafts at Lincoln and at Mt. Pulaski. One of the drill holes at Atlanta does not enter rock, although it is 151 feet deep.

According to Worthen[1] the outcrops in this county are limited to certain exposures of limestone along Salt Creek in T. 19 N., Rs. 3 and 4 W. Most of the county is thickly covered by drift. In the vicinity of Atlanta the drift has a known thickness of over 200 feet.[2] The character of the material in the drift sheet is shown by the following record of a drilling at Atlanta.

Log of the well at the waterworks at Atlanta, Illinois

Description of strata	**Thickness**	**Depth**
Quaternary system—	***Feet***	***Feet***
Pleistocene and Recent—		
Soil, black	**3**	**3**
Clay, yellow	**15**	**18**
Clay, blue	**10**	**28**
Sand and gravel	**10**	**38**
Clay, blue	**2**	**40**
Sand and gravel	**9**	**49**
Clay, white, and sand	**7**	**56**
Clay, blue, with gas	**3**	**59**
Sand, white, and gravel	**10**	**69**
Sand	**6**	**75**

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[1] Geology of Illinois, Vol. 4, p. 184, 1870.

[2] Leverett, Frank, Illinois Glacial Lobe: U. S. Geological Survey Mon. 38, pp. 205 and 206, 1899.

Log of the Atlanta well—Concluded

Description of strata	Thickness Feet	Depth Feet
Sand, dry, and gravel with gas	13	88
Clay, blue	4	92
Clay, sand, gravel, and gas	16	108
Hardpan	9	117
Drift, black	6	123
Clay, white	2	125
Clay, green	4	129
Hardpan	10	139
Gravel and water	12	141

A less detailed record of another boring at Atlanta shows that the drift has a thickness of at least 217 feet in this vicinity.

Record of a coal prospect near Atlanta, Illinois

Description of strata	Thickness Feet	Depth Feet
Quaternary system—		
Pleistocene and Recent—		
Soil	3	3
Clay, yellow	17	20
Clay, blue	50	70
Hardpan	55	125
Drift, black	8	133
Clay, green	7	140
Hardpan	30	170
Gravel with water	2	172
Gravel and sand, cemented	18	190
Sand and gravel with water	3	193
Clay and gravel and sand	14	207
Loam, yellow	4	211
Sandstone, yellow	1	212
Clay, soft, pink	5	217
Pennsylvanian system—		
"Soapstone"	3	220
Limestone	1	221
Fire clay	3	224
Limestone(?)	53	277
Shale with clay	40	317
"Slate"	7	324
Coal (No. 5?)	4	328
Fire clay	1	329
Limestone	1	330

As the northern part of the county is crossed by a glacial moraine, the drift is thicker there than it is in the southern part. At Lincoln and Mt. Pulaski records show that the glacial covering is generally between 75 and 100 feet deep. Because of the difficulties attendant upon sinking shafts through unconsolidated material the desirability of given areas for mining operations becomes less as the thickness of the drift increases. Accordingly the exploitation of the coal resources of the northern part of Logan County will probably be greatly delayed with respect to the development of the southern part, especially as the character and thickness of the coal is apparently as good in the southern portion as it is in the northern.

COAL-BEARING ROCKS

The character of the coal-bearing strata of the county is known from the record of the Atlanta coal prospect given above, and the few outcrops noted above, and from the following records of three other holes:

Record of the shaft of the Citizens Coal Mining Company, Lincoln, Illinois

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Soil and clay	18	....	18	....
Drift	3	....	21	....
Clay, blue	8	....	29	....
Hardpan	16	....	45	....
Sand and water	16	....	61	....
Sand and hardpan (water)	24	....	85	....
Gravel, coarse	3	....	88	....
Hardpan	1	5	89	5
Pennsylvanian system—				
McLeansboro—				
Fire clay	3	5	92	10
Limestone, impure	20	....	112	10
Shale, black	1	5	114	3
Fire clay	2	....	116	3
Clay, red and white	12	....	128	3
Fire clay	2	....	130	3
"Conglomerate"	12	....	142	3
"Slate," brown	30	....	172	3
"Slate," black	4	....	176	3
Coal (No. 7)	1	5	177	8
Fire clay	10	....	187	8
Sandstone, blue	22	....	209	8
"Slate," black	1	....	210	8

Record of the shaft of the Citizens Coal Mining Company—Concluded.

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Carbondale—				
Coal (No. 6?)	1	....	211	8
Fire clay	3	5	215	1
Sandstone, blue	18	....	233	1
"Soapstone"	3	....	236	1
Rock, fine blue	7	....	243	1
Shale, blue	18	....	261	1
Limestone	1	6	262	7
"Slate," black	3	4	265	11
Coal (No. 5)	5	2	271	1

Record of a boring for oil in the NE. ¼ sec. 3, T. 19 N., R 2 W., Logan County

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Soil	19	....	19	....
Gravel	20	....	39	....
Quicksand	14	....	53	....
Clay and sand in streaks	18	....	71	....
Pennsylvanian system—				
Limestone, shell	2	....	73	....
Shale, sandy	20	....	93	....
Shale, blue, mucky	8	....	101	....
Quicksand and water	25	....	126	....
Shale (mud), blue	7	....	133	....
Limestone, hard, flinty (Lonsdale?)	12	....	145	....
Shale, red, sandy	15	....	160	....
Shale ("marrow"?), blue	5	....	165	....
Limestone, shell	2	....	167	....
Shale, red	10	....	177	....
Shale ("marrow"?), blue	30	....	207	....
Limestone, shell	2	....	209	....
Shale, white	16	....	225	....
"Slate," blue	4	6	229	6
Limestone, shell	1	....	230	6
Coal, (No. 5)	4	....	234	6
Shale, white	20	....	254	6
Shale, blue	3	6	258	....
Shale, white	20	....	278	....
Limestone, shell	1	....	279	....
Shale, black	7	....	286	....
"Slate," blue	3	....	289	....
"Slate," white	20	....	309	....
Limestone, white; water	10	....	319	....

Record of a boring for oil in the NE. ¼ sec. 3, T. 19 N., R. 2 W., Logan County—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
"Slate," white	101	....	420	....
"Slate," sandy, black	5	....	425	....
Shale, white	98	....	523	....
Shale, blue	2	....	525	....
Shale, white	5	....	530	....
"Slate," black	30	....	560	....
"Slate," white	5	....	565	....
Shale, dark	12	....	577	....
"Slate," white	33	....	610	....
Shale, black	15	....	625	....
Sand, black; gas and water	10	....	635	....
"Slate," white	4	....	639	....
Coal	....	6	639	6
Shale, blue	20	6	660	....
"Slate," white	12	....	672	....
Shale, black, sandy	14	....	686	....
Shale, white	10	....	696	....
Mississippian system—				
Limestone	25	....	721	....
Sandstone	3	....	724	....
"Slate," white; streaks of limestone	18	....	742	....
Limestone	20	....	762	....
Sandstone; salt water	8	....	770	....
Limestone	4	....	774	....
Shale, sandy	5	....	779	....
"Cap rock"	1	6	780	6
Sand, gas	1	6	782	....
"Cap rock"	7	....	789	....
Limestone, hard and soft layers	81	....	870	....
Shale, sandy, dark	3	....	873	....
"Cap rock"	3	....	876	....
Sandstone; salt water	14	....	890	....
"Soapstone"	1	....	891	....
Shale, dark	3	....	894	....
"Cap rock," hard	1	....	895	....
"Cap rock"	2	....	897	....
Sandstone, dark	....	4	897	4
Sandy shale, dark	1	....	898	4
"Cap rock"	1	....	899	4
Sandstone; gas	....	4	899	8
Rock, very hard	8	4	907	—

Record of a coal mine shaft, Mount Pulaski, Illinois[1]

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent				
Drift clay and gravel	92	....	92	....
Pennsylvanian system—				
Shale, sandy	20	....	112	....
Limestone	1	....	113	....
Fire clay	1	6	114	6
"Slate," gray	20	....	134	6
Shale, sandy	40	....	174	6
Limestone	2	....	176	6
Shale, black	1	....	177	6
Coal (No. 8?)	1	6	179	....
Fire clay	2	....	181	....
Shale, clay	4	....	185	....
Shale, gray, sandy	60	....	245	....
Limestone, conglomeratic	15	....	260	....
Shale, clay	2	....	262	....
"Slate," black	1	....	263	....
Coal	....	6	263	6
Fire clay	....	6	264	....
"Slate," black	....	10	264	10
Coal	....	4	265	2
Fire clay	....	8	265	10
Shale, reddish	10	....	275	10
Sandstone	30	....	305	10
Shale, sandy, clay	30	....	335	10
Limestone, black	8	....	343	10
Coal (No. 5)	4	....	347	10
Fire clay	4	....	351	10

The foregoing records differ so much from one another that it is impossible to make a generalization that is of much value in regard to rock succession in the county. The only workable coal in the section, however, seems to be No. 5, at least under present conditions. The only drill hole penetrating the horizon of No. 2 coal is the oil prospect, and as this was drilled by a churn drill, the details are not to be relied upon for accuracy. The absence of a coal which can be correlated with No. 2 in this record is of no great significance.

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[1] Geological Survey of Illinois, Vol. 8, p. 51, 1890.

Mine Notes

MINE OF THE CITIZENS COAL MINING COMPANY, AT LINCOLN

Entrance: Shaft; 266 feet to the top of No. 5 coal.

Thickness of coal: Averages 5 feet 2 inches; maximum observed, 6 feet.

Character of the coal: The bed lies in a single bench with no persistent partings. It contains a few thin streaks of mother coal or "black-jack" (pyritized mother coal), commonly less than 1/16 of an inch in thickness. Pyrite lenses and balls are uncommon in the coal. Horsebacks are numerous and vary in width from mere cracks with pyrite filling to openings 3 to 4 inches in width, filled with clay. Rarely the horsebacks or clay slips are as much as 2 feet across. As a general thing the clay veins do not seem to be quite so hard and difficult to handle as are those in some of the mines in the Peoria region. However, the expense of the dead work produced because of the presence of the clay vein is a considerable handicap against the profitable operation of this mine.

Character of the roof: The immediate roof is a black shale which in places is hard and sheety, carrying niggerheads. Over much of the mine, however, the black shale is more massive, softer and thicker, and tends to break out in chunks rather than in sheets. This sort of roof is difficult to hold, especially as the limestone cap-rock is also thin or absent at these places. The cap-rock is a thin gray to whitish limestone, discontinuous in distribution and varying considerably in thickness, but generally present. Where the black "slate" is hard, sheety, and about 3 feet thick, the cap-rock is generally believed to be present, and to be thicker and harder than elsewhere, possibly 12 to 15 inches thick. That this is actually the case must be inferred from the few places where the "slate" has been taken down, as under ordinary conditions it does not fall so that the roof can be seen. Elsewhere the limestone is more clayey, softer, thinner, and in places entirely absent.

Between the coal and the better "slate" roof there is generally a ¾-inch sheet of pyrite, which sticks to the roof rock and remains up. Where the pyrite is present in this manner, the roof is easier to hold; and the absence of the pyrite band generally indicates that roof conditions will be bad.

Character of the floor: Underclay lies beneath the coal. It has not been penetrated but is known to be 5 to 6 feet thick in places. The clay heaves some when it is wet.

The mine encounters some difficulty in handling the water that enters the shaft from a gravel bed 45 to 61 feet from the surface, as shown in the record given above. It is evident that this water was not properly sealed off at the time the shaft was sunk.

MINE OF THE LATHAM LINCOLN COAL COMPANY, AT LINCOLN

Entrance: Shaft; 280 feet to No. 5 coal.

Thickness of coal: Varies from 4 feet 8 inches to 5 feet 3 inches; averages 5 feet.

Sections of the coal:

SECTIONS OF NO. 5 COAL IN MINE OF LATHAM LINCOLN COAL COMPANY, LINCOLN, ILLINOIS

Section 1—Room 3, off first stub off straight south entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, hard	..	5
Mother coal, soft	..	½
Coal, dirty	2	4
Pyrite	..	⅛
Coal, clean and bright	..	3
Pyrite lens	..	⅞
Coal, dirty, bright	1	10½
	5	0

Section 2—Room 1, off second right off straight east entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, bright, hard	..	3
Mother coal	..	¼
Coal, fairly clean	2	4½
Mother coal	..	¼
Coal, dirty	..	5¼
Pyrite	..	¼
Coal, very dirty	1	9
	3	10½

Section 3—Room 2, off second stub off third right off north entry[1]

	Thickness	
	Ft.	*in.*
Roof: Black slate	..	..
Pyrite	..	¼
Coal, fairly clean and hard	2	½
Mother coal	..	¼
Coal, dirty	..	2
Pyrite	..	1
Coal, dirty	1	3½
Coal, bony (pyrite and black jack)	..	2½
Coal, very dirty	1	2½
Floor: Underclay	..	..
	5	½

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[1] U. S. Bureau of Mines Bull 22, p. 497.

Section 4—[illegible]

	Thickness	
	Ft.	in.
Roof: Shale		
Coal		10
Sulphur		½
Coal	3	[illegible]
Sulphur		¼
Coal		[illegible]
Floor: Shale		
	4	[illegible]

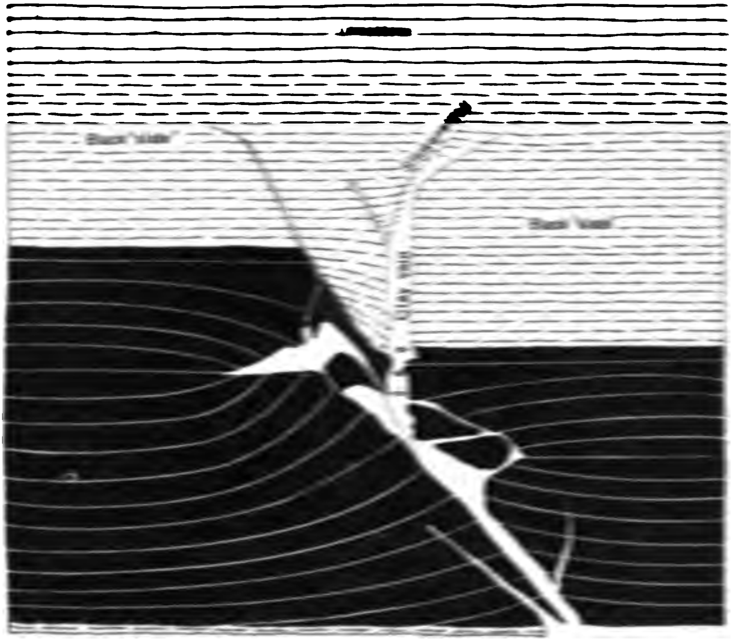

Fig. 7.—Sketch of a clay vein "horseback" in the Latham-Lincoln Coal Company's mine at Lincoln.

Section 5—[illegible] feet [illegible] of the third [illegible]

	Thickness	
	Ft.	in.
Roof: Shale	..	..
Coal		4½
Shale		¾
Coal	..	9
Sulphur	..	⅛
Coal	3	8
Floor: Shale	.	..
	4	10⅜

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[1] Op. cit.

Character of the coal: The coal lies in a single bench with no persistent impurities. There are thin mother-coal partings and the lower 2 inches of the bed in places contains bony coal. There is very little pyrite present. Usually also the top 2 inches of the coal is bony. Clay veins or "horsebacks" are rather numerous. The accompanying reproduction of a sketch of one of the clay veins (fig. 7) shows the way in which it plays out in the roof shale.

Character of the roof: The roof is a carbonaceous and sheety black "slate," commonly about 3 feet thick. Above the "slate" is a few inches of dark shale or clod upon which lies the cap-rock. This is a dark-gray fossiliferous limestone, the bottom of which is nodular and uneven. The thickness of the cap-rock averages 8 to 10 inches, but varies from 1 to 18 inches. Overlying the cap-rock there is usually soapstone or gray shale. At the base of the black "slate" and in contact with the coal there is usually a shell of pyrite 2 to 3 inches thick. This generally stays up, forming a good roof. Niggerheads are common along the contact of the coal and "slate."

Character of the floor: The fire clay is said to be 12 feet thick. It slakes in the air and heaves when wet.

MINE OF MT. PULASKI COLLIERY COMPANY (ABANDONED), AT MT. PULASKI, ILLINOIS

Entrance: Shaft 365 feet deep. Figure possibly refers to depth to the top of No. 5 coal.

Thickness of coal: Varies from 3 feet 6 inches to 4 feet 4 inches, averaging 4 feet.

Section of the coal:

Section of No. 5 coal in mine of the Mt. Pulaski Colliery Company, Mt. Pulaski, Illinois

Room 9 off back east entry off main south; 200 feet from shaft

	Thickness	
	Ft.	*in.*
Coal	1	9
Pyrite	..	1½
Coal	1	..
	2	10½

Character of the coal: The coal is all fairly hard and blocky. Pyrite is present in regular streaks but is fairly common. Clay veins or "horsebacks" are numerous, varying in thickness from 2 inches to 2 feet.

Character of the roof: The roof is black "slate" up to 4 feet in thickness.

Character of the floor: The underclay beneath the seam is said to be 10 feet thick. It tends to heave somewhat.

McLEAN COUNTY

PRODUCTION AND MINES

Production in tons, year ending June 30, 1920	43,357
Average production, 1916-1920	71,308
Total production, 1881-1920	5,478,350

McLean County ranked 37th in 1920, having a total production of about 0.05 per cent of the entire output. The output was from one mine, that at Bloomington. The Colfax mine reported no production. Table 6 gives data concerning both mines.

SURFICIAL DEPOSITS

Like most of the counties in central Illinois, McLean County is covered by glacial drift, and in this county its thickness averages probably over 200 feet. Leverett[1] makes the following statement concerning the thickness of the drift:

> **"The drift is of great depth, averaging probably over 200 feet. Records of ten deep borings were obtained which reach rock at an average of 155 feet, but twenty-one others have an average depth of 174 feet without entering rock. The drift is apparently thinnest in the northern part of the county, where rock is struck at about 100 feet. The drift in the central and southern portions has a depth of 200 to 250 feet. Buried soils are found at two or more horizons at depths usually of 100 feet or more, but on the plain outside the morainic system a soil occurs at 40 feet or less. The drift above the first buried soil is usually a soft blue till. At greater depths the till is frequently found to be very hard, as in the neighboring counties to the north and northeast, already discussed. In some of the deep borings a large amount of sand and gravel is found in the lower part of the drift. Many wells have been sunk to a depth of 150 to 200 feet in order to reach the water-bearing beds beneath the blue till, there being only a small amount of water-bearing gravel interbedded with the blue till."**

COAL-BEARING ROCKS

Because of the thick covering of glacial material and the consequent lack of outcrops, the geology of the coal-bearing rocks can be determined only by borings or shafts. The only available information of the sort is the record of two drill holes at Saybrook, and three drill or shaft records at Bloomington. The record of a deep boring for oil at Heyworth is too generalized to be of service in these studies.

Such of these records as are not confidential are reproduced herewith.

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[1] Leverett, Frank, Illinois Glacial Lobe: U. S. Geological Survey Mon. 38, p. 693, 1899.

Record of the shaft of the Bloomington Coal Company[1]

Description of Strata	Thickness Ft.	Depth Ft.
Quaternary system—		
Pleistocene and Recent—		
Surface soil and brown clay	10	10
Clay, blue	40	50
"Hardpan," gravelly	60	110
Mold, black; pieces of wood, etc.	13	123
"Hardpan" and clay	89	212
Mold, black, etc.	6	218
Clay, blue	34	252
Quicksand, buff and drab; fossils	2	254
Pennsylvanian system—		
McLeansboro—		
Shale, clay	16	270
Sandstone	32	302
Shale, clay	1	303
Coal (No. 6 or 7)	4	307

Record of the shaft of the McLean County Coal Company, Bloomington, Illinois.

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Surface soil and gravel	19	7	19	7
Clay, blue	61	2	80	9
Sand (water)	4	....	84	9
Clay, blue	76	4	161	1
Pennsylvanian system—				
McLeansboro and Carbondale—				
"Soapstone"	39	....	200	1
Limestone	1	....	201	1
Clay, blue	35	5	236	6
Clay, yellow	15	10	252	4
Shale	4	....	256	4
Sandstone, soft, gray	11	....	267	4
Limestone, hard, conglomerate	12	6	279	10
"Soapstone"	5	....	284	10
Coal (No. 7?)	3	6	288	4
Fire clay	9	3	297	7
Sandstone, gray	4	....	301	7
"Soapstone"	22	6	324	1
Shale, dark	8	6	332	7
"Soapstone"	9	6	342	1
Fire clay	10	....	352	1

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[1] Geol. Survey of Illinois, Vol. IV, pp. 178 and 186.

***Record of the shaft of the McLean County Coal Company*—Concluded**

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Shale, gray	22	....	374	1
Shale, black ("slate")	5	....	379	1
Coal (No. 5)	4	4	383	5
Fire clay	10	....	393	5
"Slate"	3	....	396	5
Fire clay	4	6	400	11
Sandstone	20	6	421	5
"Soapstone"	62	5	484	10
Shale, black ("slate")	2	7	486	5
Fire clay	1	7	488	....
"Sulphur" rock	1	2	489	2
Shale, gray	11	1	500	3
Shale	1	2	501	5
Limestone, hard	2	1	503	6
Shale, gray	2	8	506	2
"Soapstone"	6	8	512	10
Coal (No. 2)	3	8	516	6
Pottsville—				
"Soapstone," coal, and "slate"	25	....	541	6

Record of a drilling near Saybrook, in the SE. ¼ NW. ¼, sec. 28, T. 23 N., R. 6 E.

Description of Strata	Thickness		Depth	
Quaternary system—	*Ft.*	*in.*	*Ft.*	*in.*
Pleistocene and Recent—				
Soil, dark	4	....	4	....
Clay, blue	2	....	6	....
Gravel	2	6	8	6
Clay, blue	20	....	28	6
Clay, blue, with some sand and pebbles	10	....	38	6
Sand, coarse, with some clay	12	....	50	6
Gravel, coarse, mixed with sand	45	....	95	6
Clay, hard, and gravel	55	....	150	6
Quicksand	3	....	153	6
Clay, blue	4	....	157	6
Clay, hard, and gravel	36	6	194	....
Sand and gravel; water	3	....	197	....
Sand, coarse, gray	11	....	208	....
Clay, soft, blue	1	....	209	....
Sand and fine gravel	2	....	211	....
Sand and gravel, cemented	12	....	223	....
Sand, fine, with small boulders	11	....	234	....
Sand, soft	1	6	235	6
Sand, coarse, red	2	6	238	....

Record of drilling near Saybrook—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian system—				
Sandstone, soft, red	1	....	239	....
Limestone	....	8	239	8
"Soapstone" and shale	10	9	250	5
Shale, black, and coal	....	6	250	11
Shale	16	....	266	11
Limestone	....	7	267	6
Shale, blue	6	6	274	....
Shale, with streaks of limestone	14	....	288	....
Shale, dark	1	....	289	....
"Soapstone"	3	6	292	6
Shale	4	....	296	6
Shale, with spots of limestone	14	....	310	6
Limestone, hard	15	6	326	....
Limestone and shale	8	....	334	....
Shale	19	6	353	6
Shale and sandy shale	51	....	404	6
Shale, blue, tough	8	7	413	1
Shale, soft, in loose layers	7	....	420	1
Shale, black, and coal	....	4	420	5
Coal (No. 7?)	2	6	422	11
Clay, soft	....	8	423	7
Shale, with some sandy shale	94	....	517	7
Sandstone	6	....	523	7
Shale, sandy, gray	2	....	525	7
Shale, black	1	....	526	7
Shale, dark, with limestone bands	5	6	532	1
Limestone, hard, fine	....	6	532	7
Coal (No. 6?)	1	....	533	7
Shale, clay	5	....	538	7
"Soapstone"	3	....	541	7
Shale, clay, bluish	14	....	555	7
Shale, bluish, soft	16	....	571	7
Shale, gray, hard	2	9	574	4
Coal, cannel } (No. 5?)	5	4	579	8
Coal	3	....	582	8
Fire clay and shale	6	8	589	4

The interpretation of the records is practicable to a certain extent. The lowest coal at Bloomington, at 512 feet 10 inches, is No. 2 coal, or the same bed that is mined in the Longwall field. The middle bed at 379 feet is No. 5 or Springfield coal. Both of these beds are worked in the McLean County Coal Company's mine at Bloomington. The upper coal at 285 feet is either No. 6 or No. 7 coal, but the probabilities

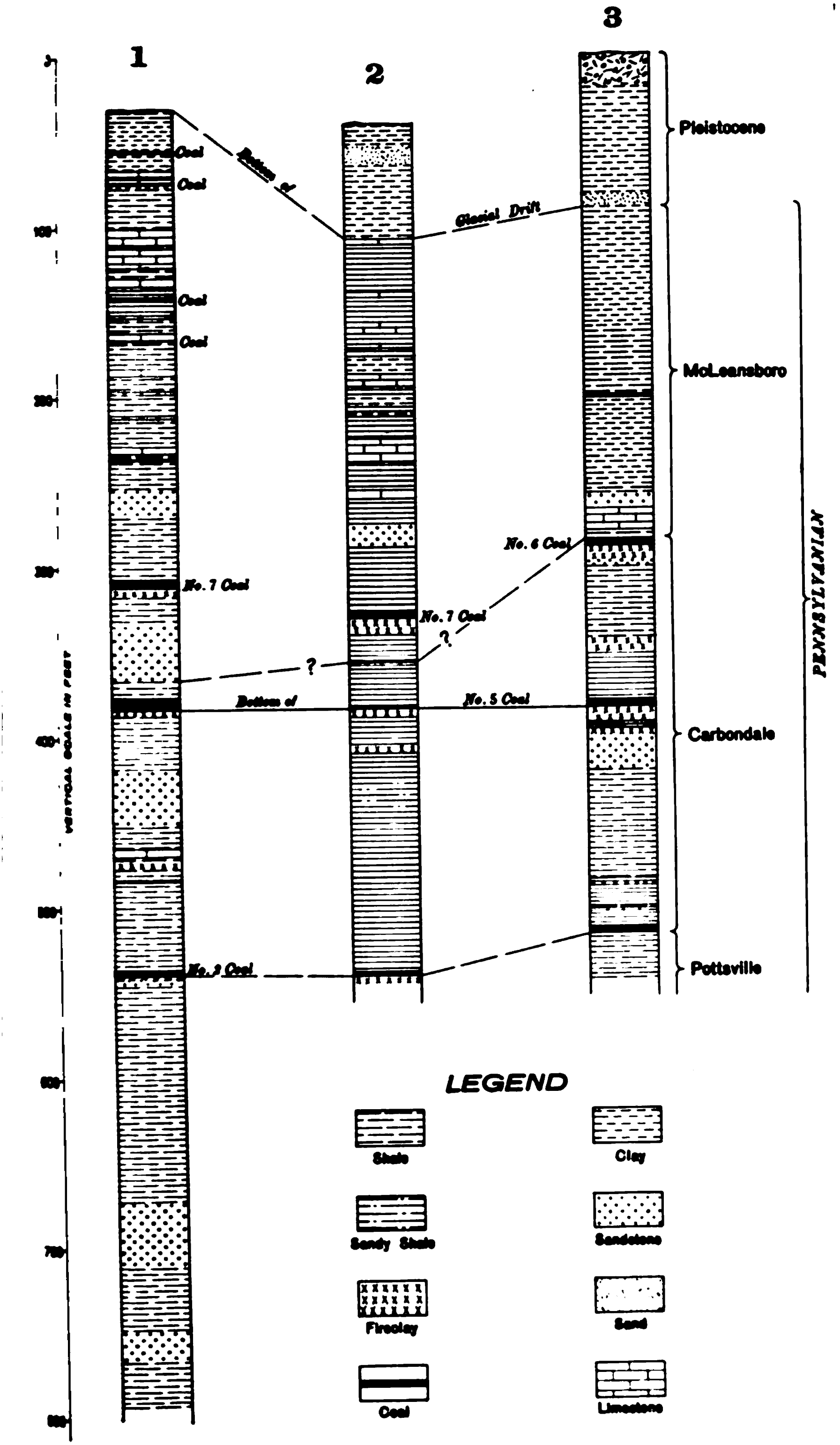

FIG. 8.—Graphic sections showing the Pennsylvanian succession at La Salle, Bloomington, and an intermediate point.

1. La Salle 2. Toluca. 3. Bloomington.

]

seem to be that it is No. 7, although Worthen regarded it as No. 6. It seems probable that this upper bed is the same as the upper bed at La Salle, which is considered to be No. 7. North from Bloomington the Pennsylvanian section resembles closely the section in the La Salle field west of the La Salle anticline as may be noted from a comparison of the accompanying graphic sections (fig. 8) showing the succession at La Salle, Bloomington, and an intermediate point, Toluca.

The coals encountered in the drilling at Saybrook can not be definitely identified, as neither the thickness nor the intervals between the coals, or the associated strata are characteristic. The writer is inclined to regard the lowermost coal and overlying cannel coal as No. 5 coal, and possibly the other two coals are No. 6 and No. 7, respectively, in their order of occurrence above No. 5. It is unfortunate that the drill did not penetrate to a greater depth, as there is a possibility that there are coals below 590 feet, which can not be proved without exploring the entire thickness of Pennsylvanian strata.

It seems quite probable that McLean County is very largely if not entirely underlain by three workable beds of coal. The upper bed may be eroded in places and is probably not as desirable as are the other two beds. This coal is probably No. 7 of the Illinois section, which is the same as the Streator coal and the upper or First Vein at La Salle. The second bed is the No. 5 or Springfield coal, which is the same as the Second Vein coal at La Salle, formerly mined at Cherry and now mined by the Matthiessen and Hegeler Zinc Company at La Salle. The lowest bed is No. 2 (La Salle) or Third Vein coal.

The coal mined at Colfax is apparently the upper bed, either No. 6 or No. 7.

Field notes are available for two mines in McLean County.

MINE NOTES

MINE OF THE COLFAX COAL COMPANY, AT COLFAX

Entrance: Shaft; 406 feet deep; No. 6? coal.
Thickness of coal: Varies from 4 to 6 feet; averages 5 feet 6 inches.
Section of the coal:

Section of the coal in the mine of the Colfax Coal Company

	Thickness *Ft.*	 *in.*
Roof: Gray shale	..	..
Coal	3	11½
Pyrite and clay	..	¾
Coal	..	11¾
Pyrite	..	1½
Coal	..	4
Floor: Underclay	..	...
	5	5½

Character of the coal: The coal lies in three benches. The bottom coal is bony and dull, with small bands of shale. The middle 11¾ inches has a dull luster with no shale bands; the upper 3 feet 11½ inches is a very bright, glossy hard coal. The seam has no regular bands of sulphur but this impurity is present in irregular lenses.

Although this coal has been designated as No. 6 by the State inspector, it does not possess the identifying characteristics such as the "blue band" and the limestone cap-rock carrying the characteristic fossil *Girtyina ventricosa*. The coal also lacks the characteristics that might correlate it with No. 5, namely, the black shale roof and "horsebacks" or clay slips. The conditions at Colfax possibly resemble those found in the mines at Fairbury and Pontiac, the coal in each of these places being worked under a gray shale roof. However, facts do not warrant a definite correlation of the Colfax coal with that at Fairbury and Pontiac. Furthermore, whether the Pontiac coal should be correlated with No. 5, No. 6, or No. 7, or with any of these coals is a question. The permanent closing of the mine at Colfax will probably make definite correlation of this coal impossible without considerable drilling.

MINE OF THE McLEAN COUNTY COAL COMPANY, AT BLOOMINGTON

Two seams, No. 5 and No. 2, are operated from this shaft.

NO. 2 COAL

Entrance: Shaft; depth to the coal 513 feet.

Thickness of coal: Averages 3 feet 8 inches; the coal maintains a very uniform thickness.

Sections of the coal:

Sections of No. 2 coal in the mine of McLean County Coal Company, at Bloomington

Section 1—Room 21, 5th south off straight west entry

	Thickness Ft.	Thickness in.
Roof: Gray shale or "soapstone"	..	..
Pyrite	..	½
Coal, clean, hard, and bright	..	9½
Mother coal	..	½
Coal, clean and bright	..	6½
Mother coal	..	¼
Coal, fairly clean	1	3
Bone	..	¼
Coal, dirty	..	5
Floor: Dark underclay	..	..
	3	1½

Section 2—Face of straight west entry, 7,000 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Gray shale	..	..
Coal, clean, bright, hard	1	4
Bone and pyrite	..	¾
Coal, clean, dull, and hard	1	..
Bone	..	¼
Coal, dull, bony	..	6
Floor: Fire clay	..	..
	2	11

Section 5—Room No. 3 off 5th north off main west entry, 7,300 feet from the shaft

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, hard, clean, and bright	..	10½
Mother coal and bone	..	½
Coal, clean and hard	..	5
Mother coal	..	¼
Coal, clean and bright	1	1
Bone	..	¾
Coal, soft, dirty	..	6½
Floor: Underclay	..	..
	3	6½

Character of the coal: The coal lies in a single bench. It is hard and tough, but seems to be lighter and cleaner than the upper bed (No. 5). Pyrite balls are rather common, but are easily separated from the coal. There are also lenses of "black jack," which apparently consists of mother coal impregnated with pyrite. These lenses are about as hard as pure pyrite nodules. There is a fairly continuous band of pyrite 4 to 8 inches above the bottom of the bed. This is lenticular in character, the lenses thickening up to about 1 inch. About 1 foot from the top there is a streak of dirty coal 4 to 5 inches thick in part of the mine. The pyrite balls attain a thickness of 6 to 8 inches by 24 inches across, but more commonly they are 1 to 1½ inches thick and 6 to 8 inches across. This coal is said to be dry because it does not "sweat" like the upper coal.

Character of the roof: The typical roof is gray shale, called "soapstone," which is generally about 10 feet thick. In places, however, it has a thickness of 20 feet, and in other places is absent, the black "slate" which elsewhere overlies it resting here upon the coal. The "soapstone" resembles in all respects the shale roof of No. 2 coal noted at La Salle and in the Pottstown mine in Peoria County. It is a fine-grained gray shale, containing small nodules, which weather to a brownish color. The black sheety shale, or "slate," also resembles its counterpart in the La Salle and Peoria regions. It is about 3 feet thick and in places contains large niggerheads or limestone concretions. The coal is reported to be somewhat thinner under the black "slate" than under the gray shale. Where the shale overlies the coal and contains large niggerheads, they may extend well down into the coal, cutting it out in a small area. The coal under the "slate" is spoken of by the miners as being "depressed," as though it had been crushed. There is said to be more pyrite in the coal in this situation; this opinion could not be verified, however, although it may be the case.

The miners speak of the gray shale, overlying the black shale, as the cap-rock. There is no true limestone or sandstone within a short distance above the coal.

Character of the floor: The underclay below the coal is said to have a thickness of about 3 feet. This clay heaves somewhat. The gob from the mine including the floor clay has been used in brick manufacture by a neighboring plant within recent years.

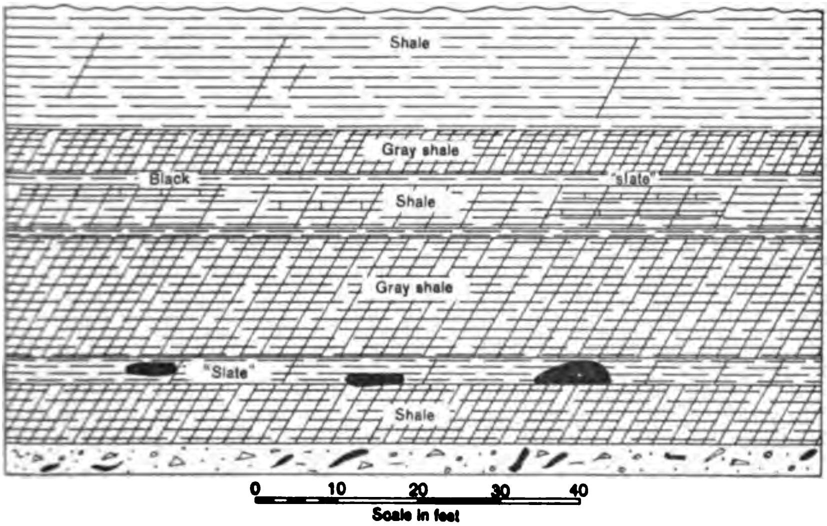

FIG. 9.—Section of the slope between No. 2 and No. 5 coals in the McLean County Company's mine at Bloomington, showing diagrammatically the character of the intervening strata and the cracking resulting from subsidence.

NO. 5 COAL

Entrance: A slope extends from the upper seam to No. 2 coal down which the coal is run to the shaft, where it is hoisted to the top. The bottom of No. 5 coal lies at a depth of 380 feet, according to Worthen,[1] there being an interval of about 130 feet between the two coals. The slope between the beds shows the character of the intervening strata and the effect of subsidence is clearly shown in the walls. The section as measured roughly and the amount of cracking in evidence is given herewith and is shown diagrammatically in Fig. 9.

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[1] Geological Survey of Illinois, Vol. 4, p. 185, 1870.

Section of strata measured in slope between No. 5 and No. 2 coals in mine of the McLean County Coal Company

Description of Strata	Thickness		Depth	
	Ft.	in.	Ft.	in.
Coal (No. 5)	4	....	4	....
Fire clay	2	....	6	....
Shale and sandy shale	12	....	18	....
Shale, black	....	11	18	11
Coal	....	1	19	....
Fire clay	5	....	24	....
Shale, sandy and clay shale	15	....	39	....
Shale, lime; few cracks near bottom	60	....	99	....
Shale, gray, cracked	5	....	104	....
"Slate," black; not cracked	1	....	105	....
Shale, limy; cracked slightly	5	....	110	....
"Slate," black; few cracks	1	....	111	....
Shale, gray (cap-rock); cracked	15	....	126	....
"Slate," black; few cracks	3	....	129	....
Shale; "Soapstone"; cracked	11	....	140	....

The preceding section may be compared with the following log of the shaft between the two coals as given by Worthen.[1]

Section of strata between No. 5 and No. 2 coal encountered in the shaft of the McLean County Coal Company

Description of Strata	Thickness		Depth	
	Ft.	in.	Ft.	in.
Coal (No. 5)	....	....	....	....
Fire clay	10	....	10	....
"Slate"	3	....	13	....
Fire clay	4	6	17	6
Sandstone	20	6	38	....
"Soapstone"	62	5	100	5
Slate, black	2	7	103	....
Fire clay	1	7	104	7
Sulphur rock	1	2	104	9
Slate, gray	11	1	116	10
Shale	1	2	118	....
Limestone, hard	2	1	120	1
Slate, gray	2	8	122	9
"Soapstone"	6	8	129	5
Coal (No. 2)	3	8	133	1

Thickness of coal: Averages about 4 feet, varying from about 3 feet 8 inches to 4 feet 6 inches. The bed maintains a nearly uniform thickness.

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[1] Op. cit.

Sections of the coal:

Sections of No 5 coal in the mine of the McLean County Coal Company, Bloomington, Illinois

Section 1—Face of straight west entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, hard, bright	1	6½
Pyrite	..	⅛
Coal, clean, bright, hard	..	10½
Pyrite	..	⅛
Coal, clean, bright, hard	..	9
Pyrite	..	⅛
Coal, fairly clean, hard	..	11
	4	1⅜

Section 2—Straight east entry, 600 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Black "slate"	..	..
Coal, bright	1	8
Sulphur	..	1
Coal, bright	..	5
Sulphur	..	½
Coal, bright	1	4
Sulphur	..	¼
Coal, dull	..	3
Floor: Fire clay	..	..
	3	9¾

Section 3—North side of pillar, 150 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Black "slate"	..	..
Coal, bright	1	7½
Sulphur	..	¾
Coal, bright	..	4
Sulphur	..	¾
Coal, bright	..	7
Sulphur	..	⅛
Coal	..	2
"Blackjack"	..	½
Coal, bright	..	5
"Blackjack"	..	9
Coal, bright	..	9
Floor: Underclay	..	..
	4	10⅛

Character of the coal: The coal is rather impure because of numerous pyrite streaks and plates, and numerous horsebacks. The pyrite plates are commonly less than a quarter of an inch in thickness and not readily removed from the coal, though an attempt to reject all pyrite is made. None of the pyrite lies persistently at one horizon. The horsebacks are of the usual sort; they are somewhat harder than those found in the Peoria region, however, due to the unusually high pyrite content. Pyrite veins or "spar" veins are also rather common. The coal is also commonly impregnated with pyrite for several inches either side of a clay or "spar" vein, so that the percentage of coal discarded on account of the horsebacks is high. In general, the coal presents no unusual characteristics.

Character of the roof: The immediate roof is a very fine black shale, 1 to 7 inches in thickness, which is almost a cannel coal. The contact between the coal and "slate" is very close, the upper part of the coal and the slate commonly being "frozen" by an intervening layer of pyrite, so that usually the upper 2 to 5 inches of the coal is left in the roof. A persistent layer of nodular limestone about 1½ inches thick lies above the lower black "slate"; overlying this another black "slate" about 11 inches thick, containing streaks of limestone. This is overlain by dark gray shale, which is black when wet and which is called "soapstone." It is between 1 and 2 feet thick and is overlain by a hard gray shale known as the "cap-rock." There is no very good contact between the last-mentioned strata and it is probable that they grade into each other.

Character of the floor: The underclay of No. 5 coal is 2 to 3 feet thick. It has no unusual characteristics.

MACON COUNTY

PRODUCTION AND MINES

Production in tons year ending June 30, 1920	218,820
Average annual production, 1916-1920	252,426
Total production, 1881-1920	10,783,991

In 1920 Macon County ranked twenty-sixth among the counties of the State, having a coal production of about .3 per cent of the entire Illinois output. There were three shipping mines in operation, all working No. 5 coal, two at Decatur, operated by the Macon County Coal Company and the Decatur Coal Company, and one at Niantic, operated by the Niantic Carbon Coal Company. Table 6 lists the shipping mines and gives data concerning them.

COAL-BEARING ROCKS

Lying below a cover of drift, which has an average thickness of 100 feet, are the coal-bearing rocks of Macon County varying in thickness from 800 feet or less to 1,100 feet. They tend to be somewhat thicker to the south than to the north and considerably thicker to the west than to the east. Rock does not outcrop in the county, so that the geology of the coal-bearing strata is known only from drill and shaft records, seventeen in number, most of which are in the vicinity of Decatur.

From the information furnished by these records and the records of holes in adjacent counties, it appears that Macon County lies but a short distance west of the axis of the Illinois coal basin. The strata dip eastward toward the axis, so that No. 6 coal has a depth at Niantic of 310 feet, at Decatur, about 560 feet, and at Lovington in Moultrie County, 900 feet. There is also a slight increase in depth southward through the county, but it is less than the increase to the east. The eastward dip of the rock effects a thickening of the Pennsylvanian system in that direction, as noted above, and younger and younger rock underlies the drift toward the east. It is probable that the New Haven limestone, commonly found about 600 feet above No. 6 coal, outcrops below the drift in a belt running approximately north and south in eastern Macon County or western Moultrie County.

The Carlinville and Shoal Creek limestones possibly outcrop below the drift in parallel belts in western Macon County west of Niantic. One of these limestones, probably the Shoal Creek, underlies the drift in the shaft at Niantic. It seems probable, therefore, that the Pennsylvanian rock below the drift includes strata lying between the horizon of the Carlinville limestone and strata adjacent to the New Haven limestone; that is, between about 300 and about 600 feet above No. 6 coal.

In Macon County the occurrence and distribution of the coals are somewhat similar to the occurrence and distribution in Sangamon County, which lies adjacent in District VII. In the extreme southern part of the county No. 6 is probably present in commercial thickness, but as far south as Moweaqua, Shelby County, No. 5 coal is possibly of as great or greater importance. In the northern part of the county No. 6 coal plays out, so that only No. 5 coal can be mined. Thus a thinning of No. 6 comparable to the thinning of that coal in Sangamon County exists in Macon County.

No. 2 coal in a thickness not known to exceed 2½ feet, is probably present 150 to 175 feet below No. 5. No. 1 coal, mined at Assumption in Christian County, is also present, possibly generally, about 100 feet below No. 2, with a maximum known thickness in the county of about 3 feet. It is doubtful whether either of the lower coals is at present of workable thickness in competition with the thicker overlying beds.

The following records, together with the Blue Mound record given in Part I, will aid the driller and prospector in identifying beds in Macon County.

Log of air shaft at Decatur, about one-half mile southwest of the coal shaft near bluffs of the Sangamon river[1], *sec 14?, T 16 N, R. 2 E.*

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Soil and loamy clay	25	....	25	....
Sand and water (flow of 400 gallons per minute)	30	....	55	....
Clay, blue	4	....	59	....
Soil and drift wood	2	....	61	....
Sand, green	4	....	65	....
Sand, gray	6	....	71	....
Clay, hard blue	9	....	80	....
Sand and gravel (five strata)	37	....	117	....
Hardpan	23	....	140	....

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[1] Geological Survey of Illinois, Vol. VIII, pp. 48-49.

Log of air shaft at Decatur—Continued

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian system—				
McLeansboro—				
Sandstone	1	6	141	6
Shale, soft	6	....	147	6
Shale, gray and blue, sandy	28	....	175	6
Clay shale	15	....	190	6
"Slate," blue	17	....	207	6
Fire clay, ferruginous	6	....	213	6
Limestone, conglomerate	7	....	220	6
"Slate," brown	10	....	230	6
Flint stone	2	6	233	....
"Slate," black	1	....	234	....
Flint rock	2	6	236	6
Coal (No. 11)	....	10	237	4
Fire clay	8	....	245	4
Shale, blue sandy	10	....	255	4
Flint stone	3	....	258	4
Clay shale	5	....	263	4
Shale, sandy	21	....	284	4
"Slate," black	2	6	286	10
Coal (No. 10)	1	....	287	10
Fire clay	6	....	293	10
Shale, black, and 1 inch of coal	8	1	301	11
Fire clay	6	....	307	11
Shale, black	3	....	310	11
Limestone, impure	1	....	311	11
Shale, brown	8	....	319	11
Sandstone	1	....	320	11
"Slate," black	4	....	324	11
Flint stone	11	....	335	11
"Slate," black	12	....	347	11
Fire clay	4	....	351	11
Limestone (Shoal Creek)	10	....	361	11
"Slate," black (No. 9 coal)	2	....	363	11
Fire clay	8	....	371	11
Clay shale	13	....	384	11
Sandstone	5	....	389	11
Flint stone	2	....	391	11
"Slate," blue	8	....	399	11
Clay shale	39	....	438	11
Sandstone, blue	1	....	439	11
"Slate," black	3	....	442	11
Coal (No. 8)	1	4	444	3
Fire clay	6		450	3
Shale, sandy	10	....	460	3
Shale, black	33	....	493	3
"Slate," hard black	5		498	3

Log of air shaft at Decatur—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Coal (local)	....	3	498	6
Fire clay	4	....	502	6
Limestone	11	....	513	6
Shale, black	4	....	517	6
Clay shale	2	....	519	6
Coal (No. 7)	....	4	519	10
Fire clay	2	....	521	10
Stone, conglomerate	3	....	524	10
Clay shale, gray and blue	14	....	538	10
"Slate," black and ½ inch of coal	4	....	542	10
Fire clay	4	....	546	10
Sandstone	7	....	553	10
Shale, gray	6	....	559	10
"Slate," black	2	....	561	10
Carbondale—				
Coal	1	4	563	2
Clay shale (No. 6)	....	6	563	8
Coal	2	10	566	6
Shale, hard gray	8	....	574	6
Limestone	2	6	577	....
Shale bituminous and coal	....	6	577	6
Fire clay	4	....	581	6
Sandstone	17	....	598	6
Clay shale	3	....	601	6
Sandstone	13	....	614	6
Clay shale, dark	8	....	622	6
"Slate," black	1	6	624	....
Coal (No. 5)	4	6	628	6

Log of well on farm of T. C. Grady, T. 18 N., R. 2 E., Maroa, Illinois.
Elevation—720 feet

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Clay	62	....	62	....
Gravel, hardpan	6	....	68	....
Clay	16	....	84	....
Hardpan	129	....	213	....
Hardpan, sandy	6	....	219	....
Clay, hardpan	54	....	273	....

Log of well on farm of T. C. Grady—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian system—				
McLeansboro—				
Limestone	15	....	288	....
Shale, light	1	....	289	....
Shale, black	2	....	291	....
Shale, gray	5	....	296	....
Limestone	4	....	300	....
Shale, light	12	....	312	....
Sand shale	30	....	342	....
Shale, gray	28	....	370	....
Limestone	10	....	380	....
Shale, gray	19	....	399	....
Shale, sandy	90	....	489	....
"Slate," dark	10	....	499	....
Carbondale—				
Coal (No. 6)	....	6	499	6
Fire clay	1	6	501	....
Sandstone, gray	3	....	504	....
Shale, light	8	....	512	....
Limestone	9	....	521	....
Shale, blue	4	....	525	....
Limestone	7	....	532	....
Sand shale	34	....	566	....
"Slate," black	3	6	569	6
Coal (No. 5)	1	6	571	....
"Slate," dark	4	....	575	....
Limestone	17	....	592	....
Sand shale	20	....	612	....
Slate, black	4	....	616	....
Shale, light	6	....	622	....
Limestone	4	....	626	....

Log of Niantic Carbon Coal Company's shaft, sec. 12, T. 16 N., R. 1 W.[1]

Elevation—585 feet

Description of Strata	Thickness		Depth	
Quaternary system—	*Ft.*	*in.*	*Ft.*	*in.*
Pleistocene and Recent—				
Soil and clay, brown	11	....	11	....
Sand and gravel	4	....	15	....
Hardpan, gravelly	25	....	40	....
Hardpan, blue	10	....	50	....
Clay, soft	15	....	65	....
Hardpan, gray	10	....	75	....
Clay, soft brown	7	....	82	....

[1] Geological Survey of Illinois, Vol. VII, p. 19.

Log of Niantic Carbon Coal Company's shaft—Concluded

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian system—				
McLeansboro—				
Limestone	10	....	92	....
Rock, blue flinty	2	....	94	....
"Slate," black	3	....	97	....
Fire-clay	6	....	103	....
Limestone	10	....	113	....
Shale, blue and gray	7	....	120	....
Shale, black	1	....	121	....
Coal (No. 9)	....	2	121	2
Fire-clay	1	....	122	2
Limestone, nodular	5	....	127	2
Clay shale	5	....	132	2
Sandstone, soft blue	16	....	148	2
Shale, gray	42	....	190	2
Coal (No. 8)	1	3	191	5
Fire-clay	2	6	193	11
Sandstone	10	....	203	11
Shale, gray	45	....	248	11
Rock, hard flinty	10	....	258	11
Shale, black	3	....	261	11
Fire-clay	9	....	270	11
Shale, blue and red	15	....	285	11
"Slate," black	5	....	290	11
Coal (No. 7)	1	3	292	2
Fire-clay	4	6	296	8
Shale, black	11	....	307	8
Carbondale—				
Coal (No. 6)	2	6	310	2
Clay shale	15	....	325	2
Shale, black	3	....	328	2
Coal (local)	....	10	329	....
Fire-clay	2	....	331	....
Shale, gray	14	....	345	....
Rock, hard, black (limestone)	1	....	346	....
"Slate," black	3	....	349	....
Coal (No. 5)	5	6	354	6

KNOWN MINABLE COALS IN MACON COUNTY

NO. 5 COAL

So far as is known, No. 5 coal is present in workable thickness below the entire area of Macon County. There has been no prospecting so far as known in the eastern part of the county and future drilling may call for a reversal of the opinion expressed about the continuity of the coal.

MINE NOTES

The best information concerning No. 5 coal is that found in mine notes taken in the various mines of the county as summarized below.

MINE OF THE NIANTIC CARBON COAL COMPANY, AT NIANTIC

Entrance by shaft; 360 feet to No. 5 coal. Working No. 5 coal, which has an average thickness of 5½ feet, varying between 5 and 6 feet. The coal contains small sulphur streaks in the upper part of the bed, but these are not persistent. The clay veins or "horsebacks," characteristic of the bed, are present. A sketch of one made near the face of the main west entry in 1912 is shown in figure 10. In this instance the filling is described as being of two kinds of rock, hard and soft. The former seems calcareous and contains pyrite. The soft part is clay. The clay veins are numerous and greatly increase mining costs.

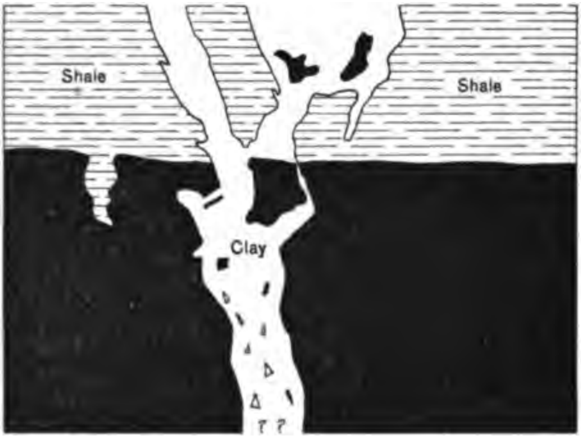

FIG 10. Sketch of a clay vein ("horseback") in the Niantic Carbon Coal Company's mine at Niantic.

The roof of the coal is commonly black shale or "slate," but varies locally from blue to gray and has a thickness of about 3 feet. Niggerheads are common in this roof. A cap-rock 4 to 12 inches thick is present above the shale.

Sections of the coal in this mine are given herewith.

Sections of No. 5 coal in Niantic mine

Section 1—3d west entry off south entry on the east side	Thickness	
	Ft.	*in.*
Roof: Shale, black	..	..
Coal, fairly clean and bright	3	..
Sulphur parting	..	..
Coal, clean and bright	..	2½
Sulphur parting	..	..
Coal, fairly clean	..	8½
Mother coal	..	¼
Coal, dirty	..	2¾
Mother coal	..	¼
Coal, dirty	..	2½
Mother coal	..	¼
Coal, fairly clean	..	7
Floor: Fire clay, dark	..	..
	5	2

Section 2—8th east off north on east side	Thickness	
	Ft.	*in.*
Roof: Shale, black	..	..
Coal, fairly clean, bright	2	6
Sulphur	..	⅛
Coal, streaked with mother coal	2	8
Floor: Fire clay, dark	..	..
	2	2⅛

Section 3—1st west off northwest entry, room 35	Thickness	
	Ft.	*in.*
Roof: Shale, black	..	..
Coal, top, local only	..	3¾
Coal, clean, bright, slightly streaked	1	8½
Sulphur parting	..	⅛
Coal, streaked with bone	..	4¼
Sulphur parting	..	..
Coal, fairly clean but with some bone	2	8¾
	5	1⅜

MINE OF THE MACON COUNTY COAL COMPANY, AT DECATUR[1]

Entrance by shaft, 560 feet to the floor of mine. No. 5 coal here has a thickness of 4½ feet and 5 feet 1 inch, respectively, where measured in two places. The coal contains some sulphur in bands or lenses, but this impurity is not in large amount. There are some horsebacks. The roof is black, fine-grained shale or "slate" containing niggerheads, which in places in the mine are numerous and of a large size. One was noted which cut out the coal to within one foot of the floor. Above the "slate" is the cap-rock, a hard limestone 10 to 24 inches thick. This is followed by gray shale, 4 to 5 inches thick, overlying which is sandstone.

---

[1] Formerly Manufacturers and Consumers Coal Company.

The following sections of coal in this mine are available.

Sections of No. 5 coal in the mine of the Macon County Coal Company

Section 1—At face, 3d left entry off the 1st east off 1st south

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, hard, bright, blocky	3	7
Coal, bony, with little sulphur	..	1
Coal, clean, bright	..	4½
Mother coal	..	½
Coal, fairly clean	..	7
Floor: Fire clay	..	..
	4	8

Section 2—Face of the 9th west off 1st south	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, bright, hard	2	4
Bone and coal	..	1½
Coal, fairly clean and hard	..	8¼
Pyrite	..	¼
Coal, fairly clean	..	7
Mother coal, soft	..	½
Coal, dirty	..	10½
	4	8

NO. 6 COAL

MINE NOTES

No. 6 coal has been mined at only one mine in this county. Conditions in the mine are shown in the following notes.

ABANDONED MINE OF THE BLUE MOUND COAL COMPANY, AT BLUE MOUND

Entrance by shaft, 472 feet to floor. The coal averages 5 feet, varying between 3½ feet and 6½ feet.

A section measured in the mine is as follows:

Section of No. 6 coal at Blue Mound, face of 1st entry off main west

	Thickness	
	Ft.	*in.*
Coal	2	6
Sulphur	..	½
Coal	..	5
Sulphur	..	½
Coal	1	6
Sulphur	..	½
Coal	..	7½
Blue band	..	1
Coal	..	9
Floor: Fire clay	..	..
	6	0

The roof in this mine is shale or limestone. The shale varies up to 3½ feet and the limestone is known to be as thick as 17 feet.

MASON COUNTY

INTRODUCTION

Coal has never been mined in Mason County and so far as is known, only one drill hole, the one located at Mason City, has penetrated the Pennsylvanian rocks.

SURFICIAL DEPOSITS

The coal-bearing rocks are deeply covered by glacial drift which in the hole at Mason City has a thickness of 204 feet. Its thickness in other places in the county is not known. Leverett says: "The county occupies a low basin-like expansion of the Illinois valley, heavily covered with sand, except where the old river channels have left a surface deposit of muck."[1]

COAL-BEARING ROCKS

Except for information afforded by the drilling at Mason City, and for a general knowledge of conditions in surrounding counties, nothing is known concerning the coal which possibly underlies Mason County. In the drill hole a coal 34 inches thick was struck at a depth of 290 to 293 feet. This thickness of the coal suggests correlation with No. 2 rather than with one of the higher coals. Further evidence in support of this correlation is that No. 5 coal at Lincoln lies at about the same depth and latitude as the coal at Mason City, whereas by reason of the regional eastward dip, No. 5 coal should be considerably higher at Mason City than at Lincoln; in fact, high enough to bring it above erosion level beneath the drift.

It is probable, therefore, though by no means established, that if Mason City is underlain by coal, it is No. 2 rather than one of the higher beds, except in the eastern part of the county, where locally the drift may be thin and one of the higher coals, possibly No. 5, may be present in small areas.

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[1] Leverett, Frank, The Illinois Glacial Lobe: U. S. Geological Survey, Mon 38, p. 688, 1899.

MENARD COUNTY

Production and Mines

Production in tons, year ending June 30, 1920	145,868
Average annual production, 1916-1920	179,861
Total production, 1881-1920	10,639,327

One shipping mine and eight wagon mines reported production in Menard County during the fiscal year 1920. The total production was a little less than .2 per cent of the State's entire output, and the county ranked thirty-first in order of production. Table 6 gives data concerning the shipping mine.

Coal-bearing Rocks

The southern part of Menard County, including the town of Tallula and others, is included in the area of the Tallula-Springfield quadrangles.[1] The north line of these quadrangles passes within less than one mile of Petersburg. The mining operations of the county accordingly lie mostly within the boundaries of these quadrangles, and the description of the coal-bearing strata on those areas given in the U. S. Geological Survey report, is adequate for the county.

The strata underlying Menard County are a continuation northward of those underlying the west half of Sangamon County. The description of these strata presented in the discussion of the coal-bearing rocks of that county will apply approximately to the strata underlying Menard County.

The rocks immediately underlying the drift are included between No. 5 coal which is thought to outcrop near the west line of the county, and the Lonsdale limestone. Accordingly No. 5 coal probably underlies the entire county, and so far as is known is everywhere of workable thickness. No. 6 and No. 7 coals are present east of their lines of outcrop, which run parallel to that of No. 5, between Tallula and the county line to the west. These coals are thin and of no commercial value. No. 2 coal is probably present but it may be too thin to be profitably worked in competition with No. 5. The interval between these coals and the character of the intervening strata have been discussed in the description of the coal-bearing rocks of Sangamon County. The reader is also referred for further detail concerning the geology of the region to the Tallula-Springfield Folio, cited above.

Only six records of drilling or shafts are available in the county, and none exceeds a depth of 165 feet. The only one of these that has sufficient detail to make it of value to this report is reproduced herewith.

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[1] Shaw, E. W., and Savage, T. E., Tallula-Springfield Folio: U. S. Geological Survey Geologic Folio 188, 1913.

Record of shaft of the Loyd coal mine in the NW. ¼ sec. 23, T. 17 N., R. 7 W.

Record given from memory by H. C. Bradt

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary stystem—				
Pleistocene and Recent—				
Clay, surface	20	....	20	....
Pennsylvanian system—				
McLeansboro—				
Limestone	7	....	27	....
Shale, blue	15	....	42	....
Rock, blue	5	....	47	....
Shale, blue	5	....	52	....
Rock, blue	5	....	57	....
Carbondale—				
Coal (No. 6?)	1	2	58	2
Fire clay	4	....	62	2
Flint rock (limestone)	4	....	66	2
Sandstone	11	....	77	2
Shale, blue and red	15	....	92	2
Cap rock (limestone?)	....	6	92	8
Slate	1	2	93	10
Coal (No. 5)	5	10	99	8

MINE NOTES

Observation has been made in four mines in Menard County.

ABANDONED MINE OF THE MIDDLETOWN COAL CO., AT MIDDLETOWN

Entrance: Shaft; 210 feet to No. 5 coal.

Thickness of the coal: Varies from 5 feet 8 inches to 6 feet 2 inches. The average thickness is 6 feet.

Section of the coal:

Section of No. 5 coal in the mine of the Middletown Coal Company, at Middletown

2d west entry off 3d south main entry, about 1,375 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Black fissile shale	..	..
Coal	2	1
Pyrite	..	⅛
Coal	1	9½
Pyrite	..	⅛
Coal	1	8
Floor: Fire clay	..	..
	5	6¾

Character of the coal: The top coal in the foregoing section is very black and brittle, and has a bright lustre. The rest is not so bright and is softer. Most of the pyrite is found in the middle portion in irregular lenses. Mother coal is less common in the upper coal than in the lower part of the bed. The bed is cut by the usual horsebacks.

Character of the roof and floor: The roof is black fissile shale 1½ to 6 feet thick, with a limestone cap-rock 4 inches to 3 feet thick. The floor is clay above limestone.

ABANDONED MINE OF THE SOUTH MOUNTAIN COAL CO., AT PETERSBURG

Entrance: Slope, 80 feet to the top of No. 5 coal.

Thickness of the coal: Varies from 5½ to 7 feet, averaging 6 feet.

Section of the coal:

Section of No. 5 coal in the South Mountain Coal Company's mine, at Petersburg

1st entry off the 7th east entry about 2,600 feet from slope

	Thickness	
	Ft.	*in.*
Roof: Shale	..	..
Coal	1	4
Pyrite	..	⅛
Coal	..	11
Mother coal		1
Coal	..	7
Pyrite	..	⅛
Coal	1	6
Pyrite	..	⅛
Coal	1	6½
	5	11⅞

Character of the coal and roof: The coal is reported to be cut by clay veins. The roof is shale, probably black, 1½ to 6 feet thick, with a cap rock of limestone 2½ feet or less in thickness usually present.

UNION FUEL COMPANY'S NO. 4 MINE, AT ATHENS

Entrance: Shaft; 203 feet to the top of No. 5 coal.

Thickness of coal: Varies from 5 to 6 feet; averages 5 feet 8 inches.

Sections of the coal:

Sections of No. 5 coal in the No. 4 mine of the Union Fuel Company, at Athens

Section 1—Room 1 off 11th north off main west entry, 6,500 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Black "slate"	..	..
Coal, bright	2	7
Pyrite	..	¼
Coal, bright	3	3
Floor: Fire clay	..	..
	5	10

Section 2—19th south off main west; entry face, 5,800 feet from shaft

	Thickness	
	Ft.	*in.*
Roof: Black "slate"	..	..
Coal, bright	..	4
Mother coal	..	½
Coal, bright	..	6
Mother coal	..	¼
Coal, bright	4	11
Floor: Fire clay	..	..
	5	9¾

Section 3—Entry face on the main east stub; 1,500 feet from shaft

	Thickness	
	Ft.	*in.*
Coal, bright	3	8
Pyrite streak	..	¼
Coal, bright	1	5
	5	1¼

Character of the coal: The coal lies in a single bed without partings. The middle of the bed contains a few pyrite lenses running parallel to the bedding, and the bottom 4 inches of the coal is bony in many places. There are no persistent impurities, however. "Horsebacks" occur with the usual frequency. The accompanying figures 11 and 12 are reproduced from sketches made of two kinds of clay veins, in one of which the fracture is about vertical and there has been no offset of the bed, and in the other an inclined fracture is accompanied by offset. Figure 11 shows also how the clay in the floor bulges up toward the "horseback" but does not enter it, the vein material being apparently entirely different from the underclay. In figure 12 it will be noted that the fracture does not extend up into the cap rock.

The coal is broken also by what seems to be true faults which cross all the strata associated with the coal. In this case the limestone rests upon the coal; the difference in the character of the fractures may be due to this fact.

The clay veins vary in width, but their maximum is about 2 feet. The filling consists of clay with small fragments of coal scattered through it. These fragments are sharp, unshattered, and have the same appearance as the coal in the bed. In one case where the floor has apparently been pushed up about 18 inches, no displacement was noted in the roof of the coal, although the fracture extended into the cap-rock, with a width of 1 to 1½ feet across, slightly less than its width in the coal.

Character of the roof: The immediate roof is usually black "slate," which varies from 6 inches to 6 feet in thickness, but averages 2 feet. In places it is less hard and sheety and becomes less like a "slate." This more massive shale is most everywhere wet and eventually falls to the cap rock. The cap rock is usually strong enough to stand where these falls occur.

The cap rock is a very carbonaceous limestone about 5 feet in thickness. Ordinarily it forms a good roof. In a few places the limestone is in contact with the coal. This contact, however, is not sharp on account of the common occurrence of coal stringers in the lower 2 inches of the rock.

The cap rock locally also cuts down through the "slate" as a "roll" under which the coal is ordinarily somewhat crushed. Overlying the cap rock is a gray "soapstone" or shale. In places the cap rock is represented

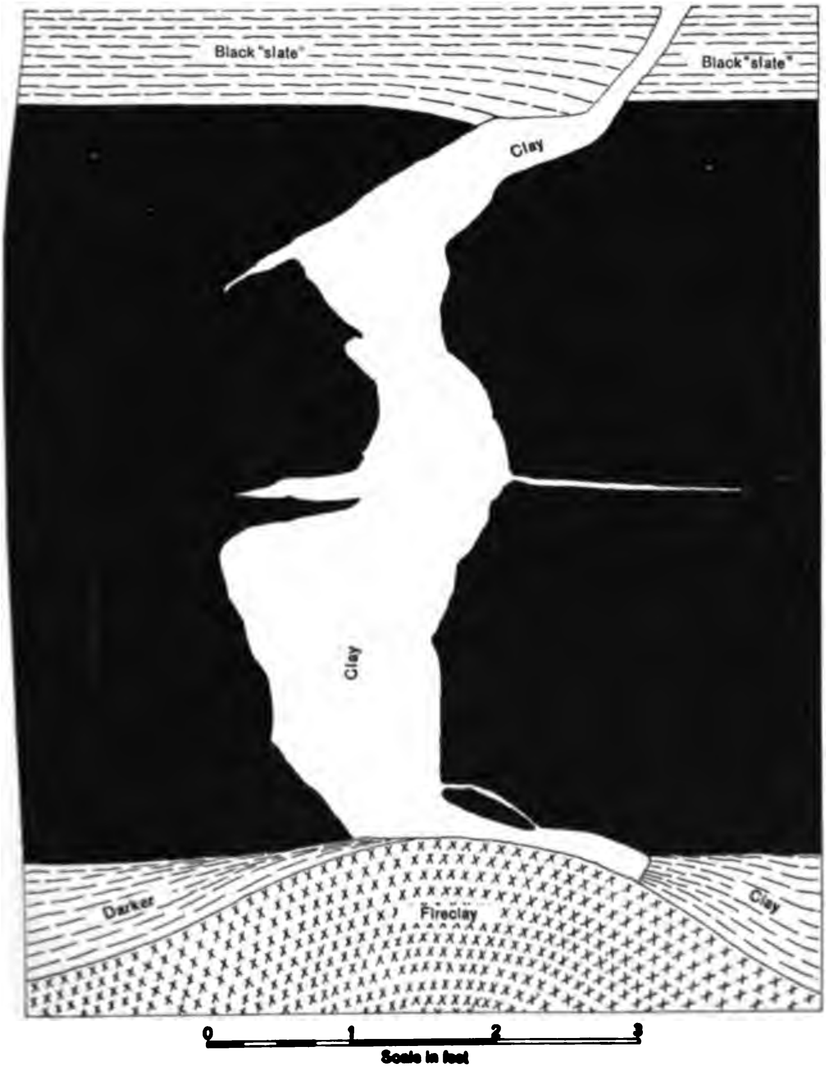

FIG. 11.—Sketch of a nearly vertical clay vein ("horseback") in the Unior Fuel Company's No. 4 mine at Athens. The fracture is not accompanied by an offset.

only by a band of boulders, the gray shale resting directly upon the black "slate," except for these nodules.

Character of the floor: The underclay is reported to have a thickness of 14 feet. The upper 7 feet is said to be rather soft and to contain many nodules or "boulders." The upper 18 inches is said to heave somewhat.

ABANDONED MINE OF THE TALLULA COAL COMPANY, AT TALLULA

Entrance: Shaft; 179 feet to No. 5 coal.

Thickness of coal: Varies from 5 feet 8 inches to 7 feet 6 inches; averages 6 feet.

Section of the coal:

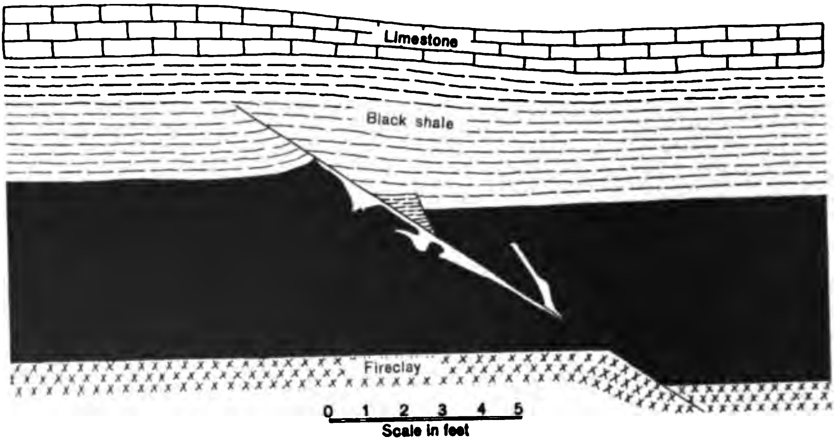

FIG. 12.—Sketch of an inclined clay vein ("horseback") in the Union Fuel Company's No. 4 mine at Athens. The bed is offset.

Section of No. 5 coal, Tallula Coal Company, at Tallula.

	Thickness *Ft.*	*in.*
Roof: Black shale	..	..
Coal	1	3
Pyrite	..	⅛
Coal	2	6
Pyrite	..	1
Coal	..	6
Pyrite	..	⅛
Coal	1	8
Floor: Fire clay	..	..
	6	¼

Character of the coal, roof, and floor: The coal bed is crossed by numerous clay veins. It has the usual black "slate" roof 14 inches to 6 feet thick, with a limestone cap rock 3 inches to 3 feet thick.

PEORIA COUNTY

Production in tons, year ending June 30, 1920	1,244,013
Average annual production 1916 to 1920	1,327,926
Total production 1881 to 1920	31,867,000

Peoria County ranked 14 in production in 1920; the output in that fiscal year (1919-1920) was 1.7 per cent of the total output of the State. During 1920 there were 2 shipping mines operating in this county and 51 local or wagon mines. The local mines produced 183,689 tons of coal. Most of the mines operated in No. 5 coal, but there was some coal mined from No. 6 coal, and plans have been made to resume operations in No. 2 coal in the Wantling (Blue Fly) mine at Pottstown.

COAL-BEARING ROCKS

The geology of the portion of this county in which mining operations are most active has been described in detail after careful field examination by Dr. J. A. Udden.[1] Much of the geological information included in the following paragraph is drawn from his publication.

The thickness of the coal-bearing strata is about 520 feet, of which the lower 300 feet is known only from drilling or mine shafts. The exposed 220 feet extends downward 20 feet below the chief productive coal bed. The most reliable and detailed information concerning the lower unexposed portion of the section is based upon the records of two shafts. One of these, located at Pottstown, passes through No. 2 coal at a depth of 106 feet, has a depth of 240 feet, and reaches a bed believed to be equivalent to the Ellisville or Rock Island coal. The workings in No. 2 coal in this mine have been reopened. The other shaft, at Orchard about 4 miles south of Bartonville, extended down to a coal bed believed to be No. 2, and equivalent to the upper bed in the Pottstown shaft. The section of strata in these two shafts follows:

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[1] Udden, J. A., Geology and mineral resources of the Peoria quadrangle, Illinois: U.S. Geological Survey Bull, 506, 1912.

Section of rocks penetrated by the shaft of the Blue Fly mine at Pottstown, west side of the SW. ¼ sec. 36, Kickapoo Township, Peoria County[1]

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Alluvium	10	....	10	....
Sand, dry	6	....	16	....
Gravel	3	....	19	....
Hardpan	2	....	21	....
Pennsylvanian system—				
Carbondale formation—				
Soapstone, white	10	....	31	....
Iron band	....	2	31	2
Soapstone	8	....	39	2
Iron band	....	3	39	5
Shale, black	20	....	59	5
Iron band	....	3	59	8
Soapstone, white	20	....	79	8
Iron band	....	2	79	10
Shale, white	4	....	83	10
Iron band	....	4	84	2
Shale, white	3	....	87	2
Iron band	....	2	87	4
Shale, dark	6	....	93	4
Cap rock	2	....	95	4
Slate, black	2	8	98	....
Shale, white	9	....	107	....
Coal (No. 2)	2	8	109	8
Pottsville formation—				
Fire clay	4	....	113	8
Sandstone	17	....	130	8
Soapstone	6	....	136	8
Sandstone, white	56	6	193	2
Clod, black	3	6	196	8
Fire clay	1	6	198	2
Coal	2	4	200	6
Sandstone, dark	4	6	205	....
Rock, hard	3	6	208	6
Clod, dark	8	....	216	6
Sandstone, hard	7	6	224	....
Slate, black	3	....	227	....
Shale	2	....	229	....
Rock, white	3	....	232	....
Coal } No. 1	1	4	233	4
Clod, black } No. 1	3	6	236	10
Coal } No. 1	3	....	239	10
Fire clay	1	....	240	10

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[1] Op. cit., p. 23.

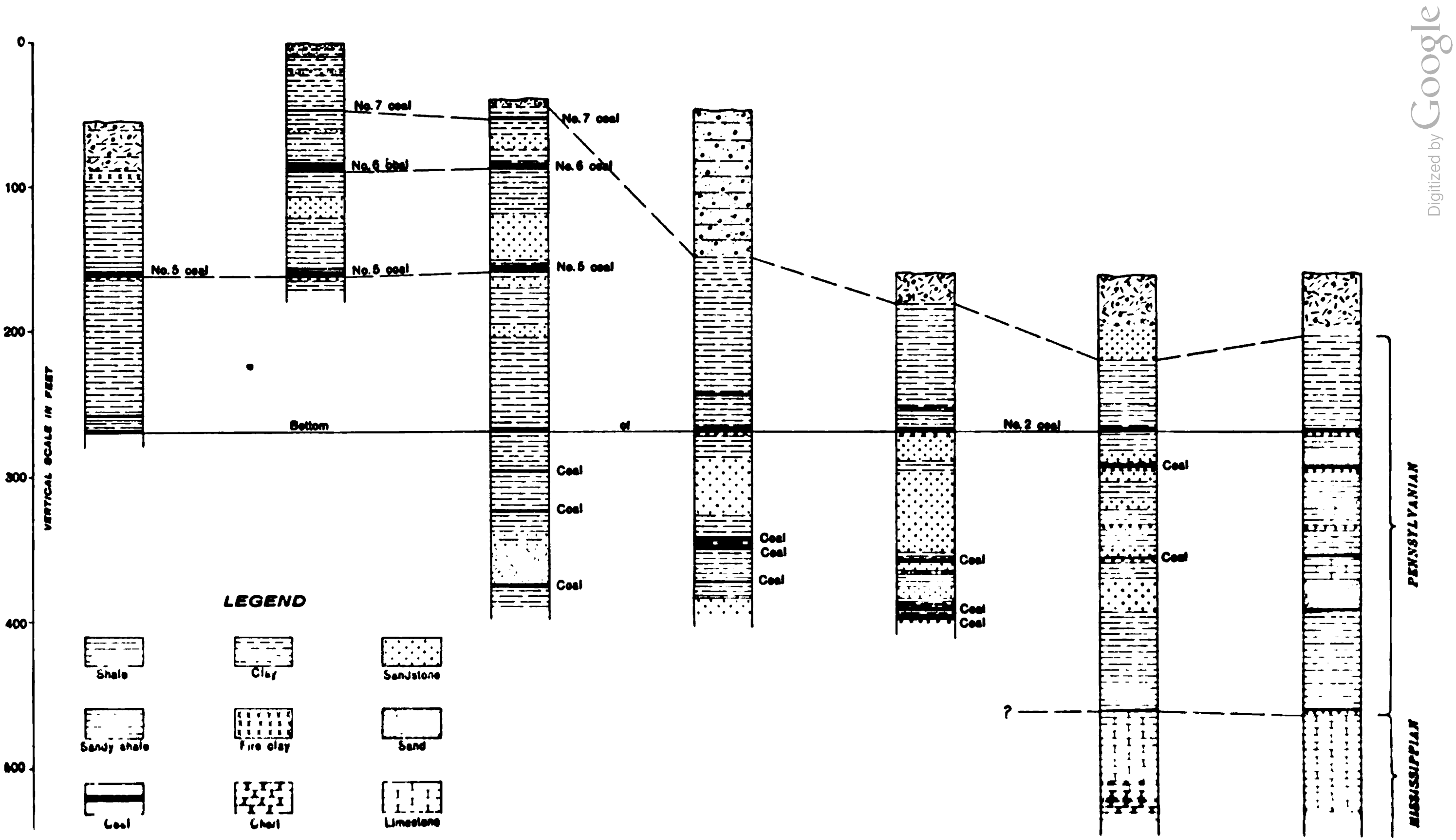

FIG. 18. Graphic sections showing the character of the Pottsville formation in Peoria County.

Section of the Orchard shaft[1], *about 4 miles south of Bartonville*

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Quaternary system—				
Pleistocene and Recent—				
Surface	3	....	3	....
"Fire clay"	2	....	5	....
Hardpan	1	8	6	8
Loam, black	3	6	10	2
Pennsylvanian system—				
Carbondale—				
Shale, black	....	9	10	11
Soapstone, soft	2	....	12	11
Shale, sandy	7	6	20	5
Limestone	2	....	22	5
Sandstone	17	....	39	5
Soapstone	4	....	43	5
Iron band	....	8	44	1
Soapstone	18	....	62	1
Sandstone, blue	4	....	66	1
Soapstone	36	....	102	1
Slate, gray, and iron band mixed	16	....	118	1
Slate, black	4	8	122	9
Hardpan	1	8	124	5
Slate, black	....	10	125	3
Soapstone	12	....	137	3
Coal (No. 2)	2	6	139	9
Pottsville—				
Fire clay	1	10	141	7

POTTSVILLE FORMATION

The succession of the Pottsville formation in Peoria County is not very definitely known. Several of the better records are reproduced graphically in the accompanying figure (Fig. 13).

Study of the available drill records, several of which are included in figure 13, indicates that the base of the Pennsylvanian system is commonly at an elevation of about 140 feet above sea level in the vicinity of Peoria. Although this figure is a generalization, it is thought to be accurate within about 25 feet. In the northwest part of the county near Princeville, the base of the "Coal Measures" is probably more than 300 feet above sea level, and along the Fulton County line near Farmington, between 270 and 300 feet. The pre-

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[1] Op. cit., p. 24.

Pennsylvanian surface accordingly probably slopes about 10 feet to the mile. There is some evidence that the surface of the Mississippian strata upon which the "Coal Measures" rest is uneven, aside from the general slope just mentioned, and therefore the Mississippian may be reached at depths which vary somewhat from what would be expected. However, if the character of the drilling chips is carefully noted when wells or tests are being put down, there should ordinarily be no difficulty in determining the base of the "Coal Measures," as at that horizon the drill passes from a succession of shales, sandy shales, and sandstones into massive limestone.

The strata in the lower 100 feet of the Pottsville are apparently mostly shale, with interbedded sandstone reported in two wells. Drill cuttings from the Glen Oak Park well, taken about 20 feet above the base of the "Coal Measures," contained coal, according to Udden.[1] Coal was reported in the Carter well in East Peoria at about the same level but was either not recorded or not present in other wells in the region. In the interval from about 100 feet above the base of the formation (at an altitude of 220 to 240 feet) up to No. 2 coal (at various altitudes between 330 and 380 feet) there seem to be several coal beds. The meager information at hand is sufficient for correlation of the coals found in the different holes. It is not even safe to assume that the coal found in several holes at an altitude of 220 to 240 feet is a continuous bed, as Pottsville coals in Illinois are characteristically lenticular, having been deposited in what apparently were local basins that probably did not synchronize.

Coal at an altitude of 226 feet and at a depth of 236 feet has been mined at Pottstown. The coal in this mine lies in two benches, the lower one according to Udden,[2] varying from 2 feet 2 inches to 3 feet, and the upper measuring 1 foot 3 inches. The two benches are separated by nearly 3 feet of shale, and the average thickness of the coal and included shale is 6 feet. Udden states that this coal bed has been recognized in no less than six of the artesian borings in the vicinity of Peoria and Pekin, but as was stated in the previous paragraph, the correlation of these lower coals upon the basis of water-well records, in several cases of doubtful accuracy, is not possible; especially is this evident when several diamond-drill holes the records of which have become available since the field work on the Peoria quadrangle was completed, show several thin coals in the section below No. 2 coal. Yet it is not at all improbable that this lower coal may be fairly continuous, at least in the southern part of the county, for it is reported in a drilling at Elmwood at the west edge of the county.

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[1] U. S. Geological Survey Bull. 506, p. 35.
[2] Op. cit., p. 25.

The strata in the upper part of the Pottsville above the lower coal, which Udden[1] suggests is the No. 1 coal, are variable. In the Pottstown shaft they are largely sandstones with a 28-inch coal bed about 40 feet above the No. 1 coal. Two records in Limestone Township report several black shales and thin coals in the succession, as well as a large amount of sandstone and sandy shales. These records both report coal between 1 and 2 feet thick about 30 feet below the top of the formation, or No. 2 coal. The record of the drilling at Elmwood shows almost continuous shale. The interval between coals No. 2 and No. 1 seems to vary from about 100 to 140 feet. It is not probable that any of the intervening coals are of workable thickness.

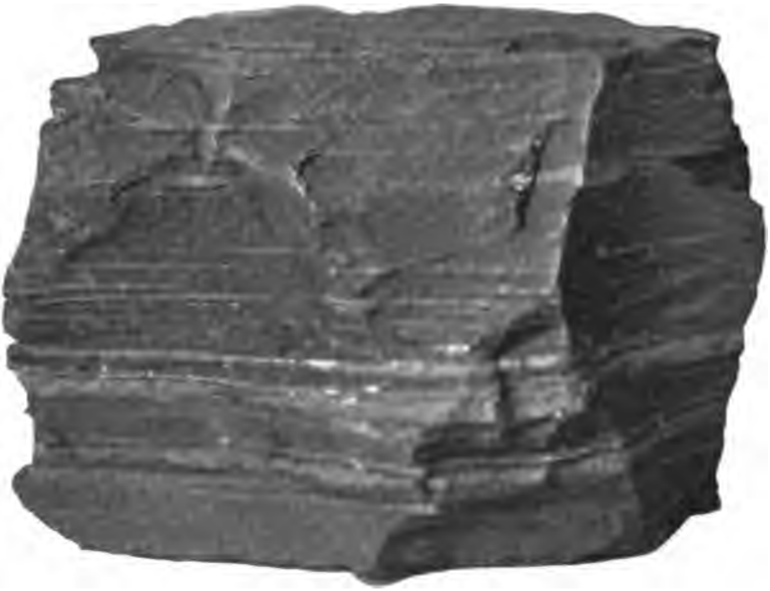

FIG 14.—Photograph of a block of the roof shale of No. 5 coal in Peoria County, showing laminated structure.

CARBONDALE FORMATION

The Carbondale formation includes all the coal beds worked in the county, and is economically the most important part of the "Coal Measures" section, not only in this county but in the State as a whole. With the exception of the small mine at Pottstown which has recently reopened an old development in No. 2 coal the commercial operations in the county are all in No. 5 coal. No. 6 coal has a little development by wagon mines at various places in the county.

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[1] Op. cit., p. 81.

NO. 2 COAL

No. 2 coal lying at the base of the formation has the usual characteristics of that bed in the northern part of the State. It is about 30 inches thick and is overlain by the gray "soapstone" and black fissile shale which is the very characteristic roof of this coal in the typical La Salle region. The coal contains the bright sulphur balls also common to this bed. Besides its similarity in appearance and occurrence as a basis of correlation with No. 2 coal, there is a similarity in the flora in the shale above this coal and in that above the coal at La Salle, which Dr. David White[1] regards as suggestive of correlation.

STRATA BETWEEN NO. 2 AND NO. 5 COALS

The interval between No. 2 and No. 5 coals varies from 110 to 140 feet, and except for the uppermost 25 feet, is known only from records of test holes, wells, and shafts. The section seems to be largely shale with some bands of ironstone or hard limestone probably containing considerable pyrite or iron carbonate, and with layers of sandstone. A few records show streaks of coal interbedded with the shale. The massive sandstone found in the upper part of the series between coals No. 2 and No. 5 in Fulton County does not seem to be generally present at least in eastern Peoria County.

NO. 5 COAL

No. 5 coal is a single bed without partings or bands and varies from about 4 feet to 4 feet 8 inches in thickness. The bed is cut by numerous clay "veins" which also penetrate the strata above the coal for an undetermined distance. When narrow and not filled with clay gouge, the vertical fractures are commonly cemented by a pyritic vein material. The coal contains several varieties of "sulphur" or pyrite, such as sulphur balls, lenses of gray and brown sulphur, sulphur spars or vein filling noted in the preceding sentence, and "blackjack" or pyritized mother coal. Of these forms probably the gray to brown lenses of laminated pyrite which occur in special abundance near the horsebacks constitute the most characteristic variety. The coal displays no physical characteristics in itself that serve to distinguish it from other coals in the State. It has the usual banded appearance of Illinois coals due to interlamination of dull and bright coal.

Distribution of No. 5 coal.—As No. 5 coal lies above the level of the present drainage lines in a considerable part of the county, it is consequently absent within the Illinois valley and for some distance up the larger tributary valleys. Above Kramm, the coal outcrops along the sides of Kickapoo Creek and is mined by drift mines.

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[1] Op. cit., p. 26.

The distribution of the coal is further limited by pre-glacial drainage lines which apparently correspond in general with those of the present, though the earlier valleys are wider and deeper than those now existing. A map of the pre-glacial surface for the whole of the county is not possible with the information now available, but Plate VI reproduced here from Doctor Udden's report[1] shows the pre-glacial surface for the Peoria quadrangle. The following description of the bed-rock surface in the Peoria region is also reprinted from the same report.

> Erosion in pre-glacial time had produced a land surface which differed considerably from the present topography. Since that time the land has been rebuilt by glaciation, the general effect of which has been to reduce the relief. The old land surface has undergone some changes by post-glacial agencies, but these are small. The present surface of bed rock is known mainly from wells and other excavations that have penetrated the drift. These data are not very numerous, but an attempt has been made to present the general features of the rock surface in the quadrangle by contour lines on a separate map (Pl. VI). Where data are wanting, the probable course of these contours is indicated by interrupted lines.
>
> In the area west of Kickapoo Creek and Illinois River, the old rock surface closely parallels that of the land today. In Limestone Township it reaches an elevation of 675 feet in secs. 5 and 6. From here it descends southward to an average height of 550 feet in the uplands of Hollis Township. The two Lamarsh creeks and Kickapoo Creek above Pottstown occupy valleys which were eroded before the deposition of the drift. Below Pottstown the last-named stream evidently has been lately crowded up on the east slope of the old upland to the west, and from Horseshoe Bottom to Bartonville it has cut a new and comparatively narrow valley on this slope.
>
> Under Peoria, and also under the upland for a distance of 3 miles north from the city, and on the east side of the river north of Farm Creek, the rock surface has an average altitude of about 400 feet above sea level. This is 200 feet lower than the same surface in Limestone and Hollis townships. It rises, however, north from Pottstown, so as to bring the "Coal Measures" again into view in some of the creeks immediately north of the north boundary of the quadrangle. South from Farm Creek, on the east side of Illinois River, bed rock rises and reaches its highest altitude of 600 feet above the sea in sec. 7, Groveland Township. Under the upland to the south it gradually sinks to an average height, as far as known, of about 525 feet in the south part of Elm Grove Township. Two wells on the lowland south of Pekin reached altitudes of 430 and 420 feet above sea level without entering bed rock. In and near the present valley

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[1] Op. cit., p. 51.

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of the river the surface of bed rock is lower than in other localities, as shown by an altitude of 355 feet above sea level at the Colean factory well, 345 feet near Iowa Junction, and 340 feet in the Pekin water-works wells.

It is not improbable that beyond the boundary of the Peoria quadrangle similar irregularities in the pre-glacial surface also exist and it is quite possible that in places lines of pre-glacial or inter-glacial drainage might have developed in positions not now occupied by streams. Such is the case in the eastern part of Fulton County and it is not improbable that some of these drainage lines extend into western Peoria County.

A third limitation upon the distribution of this coal is an intra-formational sandstone which apparently occupies channels cut through the coal some time after the No. 5 coal was deposited but prior to the deposition of No. 6 coal. In other words it is believed that after the accumulation the peat and overlying muds which later became No. 5 coal and its roof shales, land streams came into existence and cut channels into and in many places through the muds and peat; and that eventually the channels were filled with sand, which later became sandstone. The channel deposits apparently have a fairly definite alignment similar to an ordinary stream channel and probably have the usual branches or tributaries, and gradient. Along such channel lines, the coal is now absent, the bed terminating laterally against a massive sandstone, the sandstone in places presenting a nearly vertical wall, and in other places appearing first in the roof and gradually pinching the coal out toward the bottom.

In parts of Peoria County it has been possible to outline the position of the channel deposits (fig. 22), but for most of the area information on which to base a map is insufficient. As this sandstone is younger than No. 5 coal, further discussion is reserved for the following section on the strata between No. 5 and No. 6 coals.

It may well be emphasized here, however, that in exploring new properties in Peoria County the determination of the position and depth of the lines of pre-glacial drainage and the location of channel sandstones which may cut through the No. 5 coal become matters of reat importance. It is not safe to open any property in the county without learning the facts in regard to these two uncertain elements. Carelessness in this regard may result in the operator suddenly finding himself without adequate roof and even without coal.

STRATA BETWEEN NO. 5 AND NO. 6 COALS

Over No. 5 coal is a black fissile shale ("miners' slate") similar to that of Fulton County. In the course of Doctor Udden's more detailed description,[1] he mentions the whitish streaks found in this shale as shown in figure 14, and describes small calcareous nodules and the larger "niggerheads" which characterize this bed. Above the roof shale is a layer of limy shale which merges into the limestone cap-rock above. When the clay and limestone above is soft, it is generally known as clod and is very fossiliferous.[2] At the top of the clod in many places is a bed of sulphur (marcasite) 2 to 6 inches thick, the lower surface of which is very irregular due to protuberances 1 to 3 inches in height and width, called by the miners, "cat" or "cat claw." Where the marcasite is more calcareous and clayey, it is called the "iron band."

Above the clod is a shale which in most places measure 4 to 8 feet but which reaches a thickness of 20 feet locally, due to its uneven upper surface. This is overlain by a sandstone averaging 55 feet in thickness, the lower surface of which conforms with the irregularities of the uneven surface of the shale, as described above. It is this sandstone that in places continues down through the horizon of No. 5 coal, forming what have been alluded to above as the channel sandstones; and it is described by Udden as the most conspicuous unit in the exposed section of the "Coal Measures" in this region. It is present almost continuously in the west bluffs of Kickapoo Creek from Bartonville to Pottstown and in the bluffs of the same stream south of Edwards. It appears along almost every stream which drains the upland on the west side of Illinois River and Kickapoo Creek and also in some creeks near East Peoria in Tazewell County.

The sandstone just described changes somewhat abruptly into shale and fire clay above.[3] There is generally 3 to 4 feet of dark or gray, slightly sandy shale above the sandstone, which is overlain by 2 to 3 feet of fire clay of greenish-gray color. The fire clay immediately underlies No. 6 coal.

By way of summary, a section of the outcropping strata from No. 5 coal to some distance above No. 6 coal is given below.

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[1] Op. cit., pp. 29-30.
[2] Op. cit., p. 30.
[3] Op. cit., p. 32.

Section of the rocks in the west bluff of Kickapoo Creek, near the Schmidt mine near the south line of sec. 13, Limestone Township

Description of Strata	Thickness		Depth	
	Ft.	*in.*	*Ft.*	*in.*
Drift	40	....	40	....
Sandstone, thin bedded	10	....	50	....
Shale, black	....	6	50	6
Coal, impure, weathered	....	7	51	1
Coal — No. 6	1	8	52	9
Clay, red	....	3	53	....
Coal	1	1	54	1
Fire clay	1	6	55	7
Sandstone, thin bedded and fine-grained, almost shaly	19	....	74	7
Sandstone, moderately coarse, homogeneous	2	....	76	7
Sandstone, thin bedded, soft, fine grained, with thin clay seams	13	....	89	7
Sandstone, thick bedded	23	....	112	7
Shale (near mine)	9	....	121	7
Shale ("slate")	1	....	122	7
Coal (No. 5)	4	4	126	11

Discussion of the channel sandstones.—The correct interpretation of the sandstone "faults" in No. 5 coal in Peoria County is a matter of some moment to the operators in the southern part of the area, because the accepted interpretation will have considerable control over the exploration methods. They are believed by the author to be channel sandstones, but the older alternative view of Doctor Udden, presented in his report on the Peoria quadrangle and outlined below, must be taken into consideration.

The manner in which the sandstone cuts out the coal has been described very briefly in the preceding section of No. 5 coal, and additional facts about the phenomenon are to be gathered from the accompanying illustrations (figs. 15-20) and the following notes on variations in coal thickness on fractures adjacent to the "faults":

> In two of the mines along the east side of the channel sandstone or "fault" in Hollis Township (T. 7 N., R. 7 E.), the coal shows unusual variations in thickness, the bed increasing rather than diminishing in thickness, as compared with the average thickness. Sketches and figures from the mine of the Leitner (formerly German) Coal Company, indicating that in places in this mine the coal thickens to 10 feet, apparently due to duplication or overthrusting of the bed produced by lateral pressure. A similar thickening of the coal has been observed in Brewster and Evans

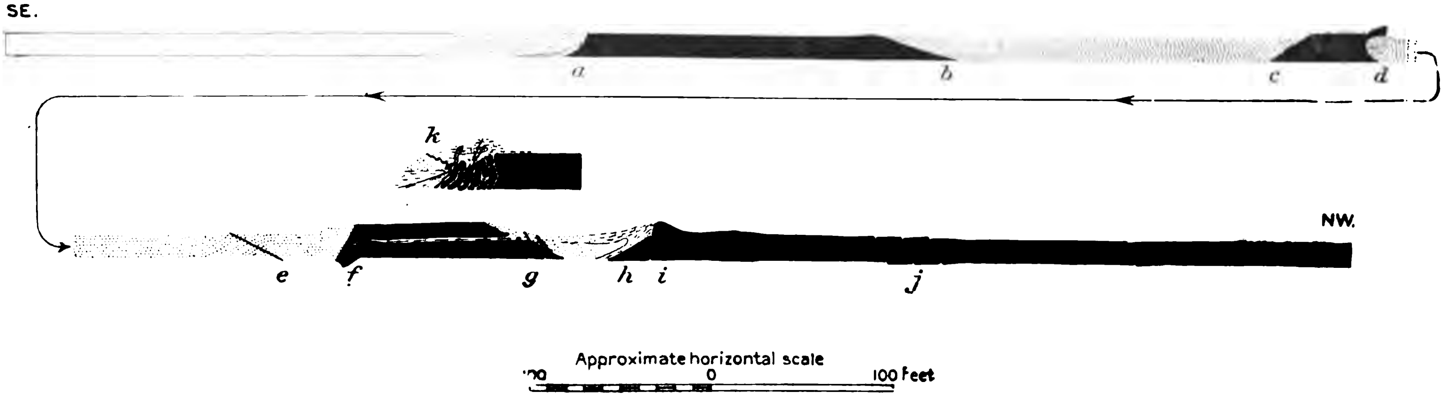

FIG. 15.—Sections of the main entry of the Leitner (formerly German) Coal Company's mine, showing the relations of the channel sandstone to the coal. See Fig. 16 for photograph at *d*; Fig. 17, at *f*; Fig. 18, at *g*; Fig. 19, at *k*, opposite *g*; and Fig. 20, opposite *h*.

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(Walben) mine in the short distance north of the Leitner mine. In the Walben mine no evidence of overthrusting was observed but the coal increased in thickness gradually from a general average of 4 feet 6 inches to 5 feet 6 inches at the edge of the "fault."

In these same mines evidence of disturbance is also seen in the folding, fracturing and shattering which affects the coal, as illustrated in figures 15 to 20. In some instances the coal is so brecciated and broken that it may be easily worked with pick and shovel.

After describing in accurate details the fractures, disturbances,

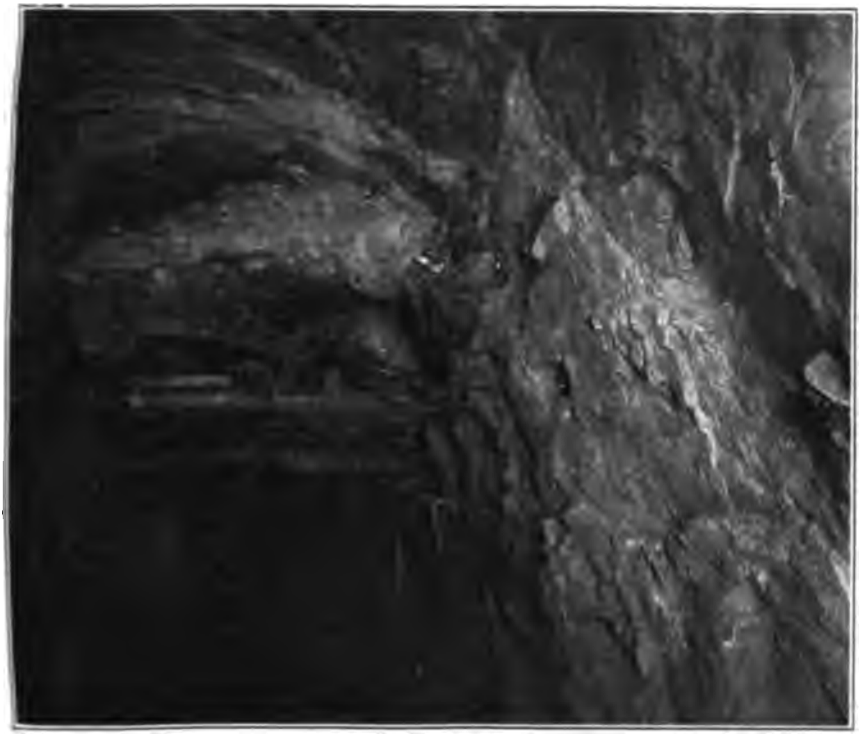

Fig. 16.—Photograph of the roof and southwest wall of main entry of the Leitner Coal Company's mine in the SE. ¼ sec. 2, T. 7 N., R. 7 E.

Looking southeast. (See fig. 15, *d.*) A projecting flange of the coal is seen in the center rising in the roof over the timbers. Several of the shearing joints show indistinct horizontal striae or flutings.

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and thickening of the coal at the contact of the coal and the channel sandstone, as summarized above, Udden[1] assigns the phenomena to glacial fracturing:

> "The author believes that the fractures are disturbances in the upper part of the soft bed rock, caused by the pressure and motion of a continental ice sheet in Pleistocene time; that they are planes marking the outlines of immense blocks of the uppermost rock strata, tens, or possibly hundreds of acres in extent, which have been dislodged from their original position, displaced, fractured, rotated horizontally and in places vertically, and partly ground into the till. He regards the region as having been a locus of incipient glacial abrasion. Instead of thoroughly triturating the grist, the glacial mill here merely blocked it out of the old land on which it spent its force."

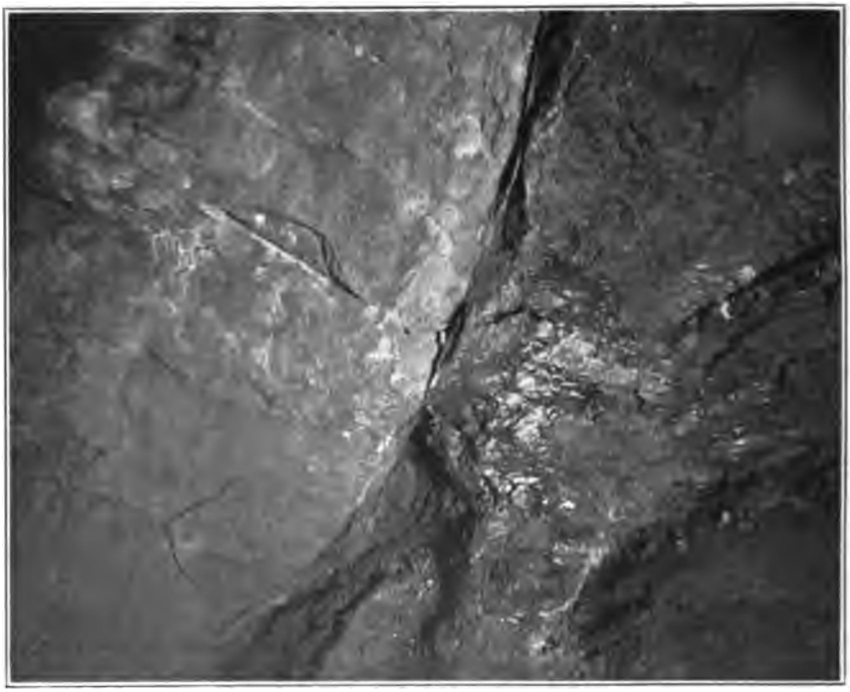

FIG. 17.—Photograph of the left (southwest) wall of the mine entry shown in Figure 16.

Looking southwest. (See fig. 15, *f*.) A fracture runs diagonally across the center of the field separating the sandstone on the left from the coal on the right. Near the sandstone the coal is shattered and mixed with fragments of shale and sandstone.

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[1] Udden, J. A., Geology and mineral resources of the Peoria quadrangle: U. S. Geological Survey Bull. 506, p. 77, 1912.

In support of Udden's theory, it is true that along the lines of the pre-glacial valleys, especially where cut into deeply by the present streams, there is abundant evidence of local dislocation by what may be called ice push. And it is also true that such localities in some instances happen to be in areas corresponding to or contiguous to the area occupied by the channel sandstone in the Lamarsh Creek basin. However, in the author's opinion, to assign the absence of the coal and other phenomena observed at the sandstone "faults," to glacial dislocation seems to call for an unusual and almost improbable exhibition of glacial activity.

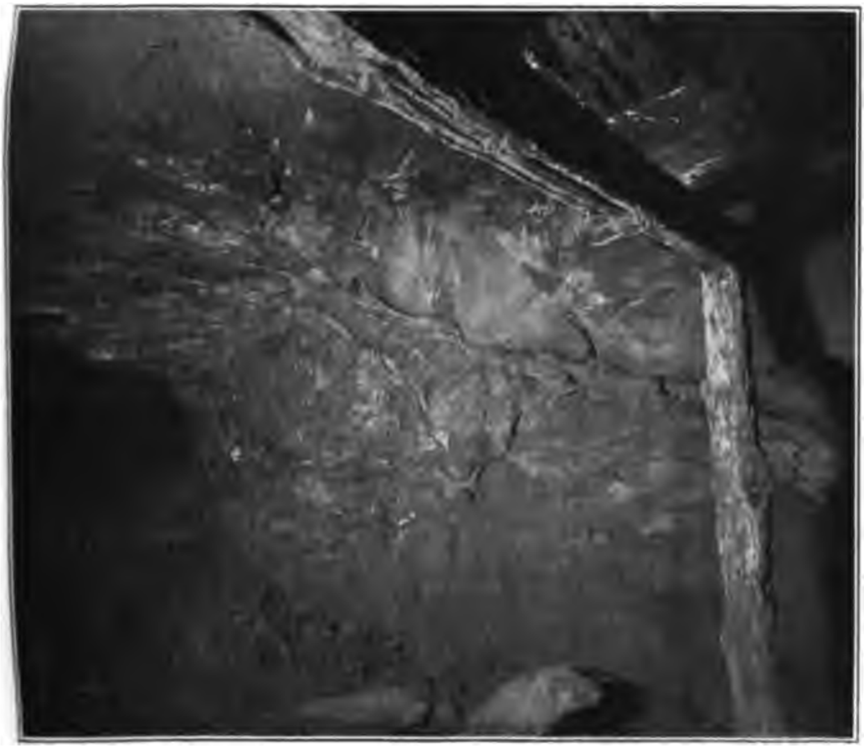

Fig. 18.—Another view of the mine wall shown in Figure 17. (See fig. 15, *g*.) An S-shaped sheared fracture is indicated by the letters *a*, *b*, *c*. Somewhat irregular indistinct horizontal flutings appear to the right of a line joining *a* and *b*.

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The author's interpretation of the sandstone "faults" is indicated by the use of the term "channel sandstone" and is outlined here in historical form:

After the accumulation of the peat and overlying muds now represented by No. 5 coal and its roof shales, land streams came into existence and cut channels into the muds and peat, thereby removing both mud and peat along their courses (fig. 21A). Eventually a layer of sand at least a score of feet thick and in many places much thicker

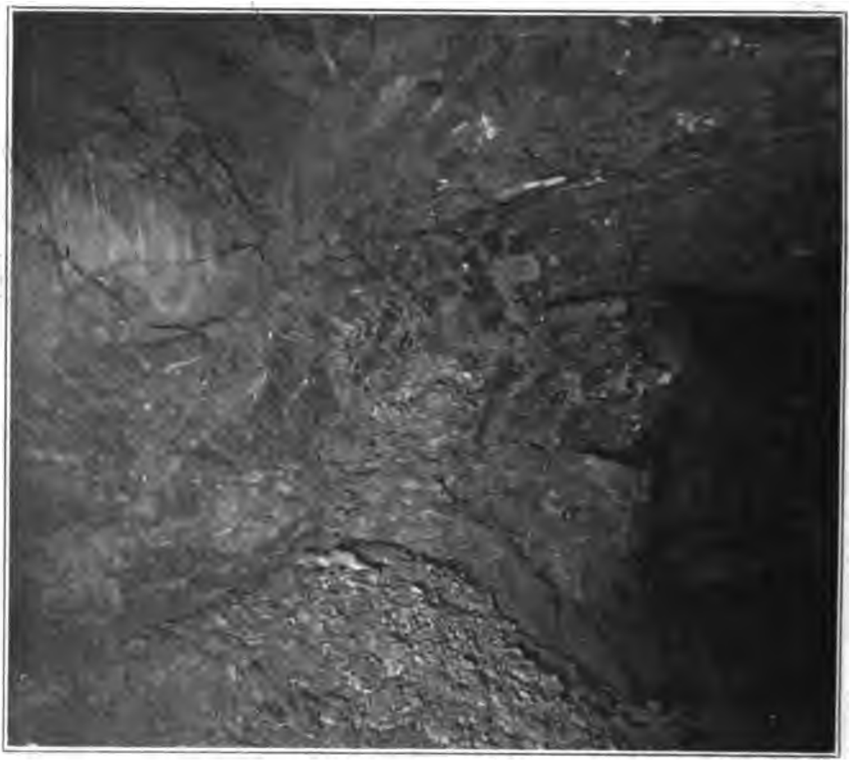

FIG. 19.—View of the right (northeast) wall of the same mine entry as Shown in figures 15, 16, 17, and 18.

Looking northeast. (See fig. 15, *k*, opposite *g*.) The fractured face of the coal appears above and to the left of the receding entry in the lower right-hand corner of the view. Horizontal flutings appear on the face of the coal at *a*. An S-shaped belt of fissured coal and shale separates the coal from the sandstone on the left, and other fissures, roughly parallel to this belt, appear indistinctly at *b*.

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was spread widely over the region, thickest of course along the positions of the channels and thinner over the intervening areas (fig. 21B). Subsequently the sand was covered over by the muds and silts upon which the peat for No. 6 coal was still later deposited. With the burial of the peat and overlying muds and sands under an increasing load of still younger sediments, the peat changed gradually into coal and the muds and sands into shales and sandstones. In such a process of consolidation, the muds and shales shrink comparatively little, but the peat is reduced to some such fraction as one-fifth of its original thickness. The consequent differential shrinkage between the strata away from the channel lines resulted in the setting up of pressures and strains which were relieved in such a way that the fracturing, coal

FIG. 20.—Another view of the mine wall shown in Figure 16. (See fig. 15, opposite *h*.) Bed *a* is dark shale with some streaks of coal, somewhat shattered, possibly the same as *b*; *b* is the roof shale of No. 5 coal; *c* is No. 5 coal; *d* is sandstone.

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thickening, and attendant phenomena exhibited at the "faults," were developed. Figure 21C is an attempt to present diagrammatically the author's idea of the way in which the forces probably acted in effecting the readjustments made necessary by the differential shrinkage.

The economic bearing of the correct interpretation of the phenomena rests upon the importance of determining the nature of the

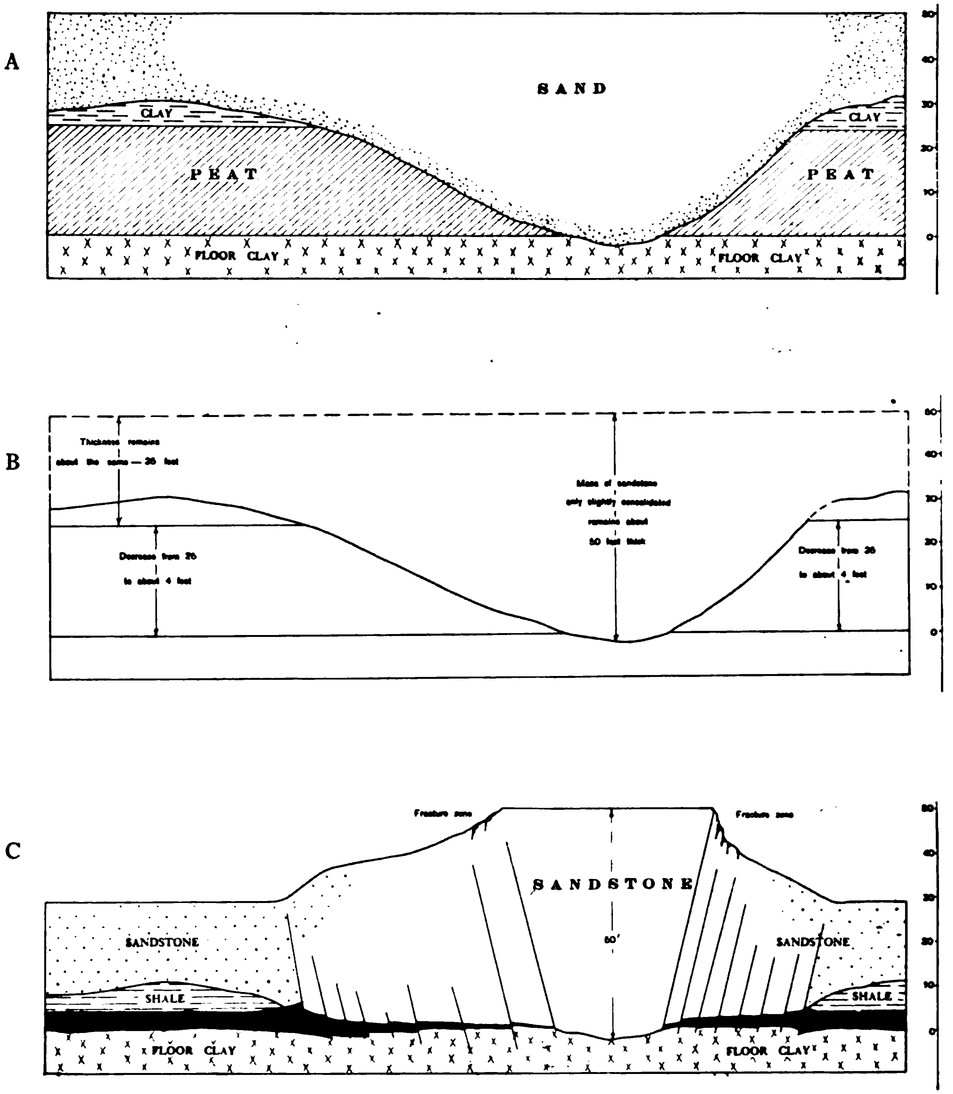
A
SAND
CLAY
CLAY
PEAT
PEAT
FLOOR CLAY
FLOOR CLAY
B
Thickness remains about the same — 25 feet
Mass of sandstone only slightly consolidated remains about 50 feet thick
Decrease from 25 to about 4 feet
Decrease from 25 to about 4 feet
VERTICAL SCALE FEET
0
10
20
30
40
50
C
Fracture zone
Fracture zone
SANDSTONE
SANDSTONE
SANDSTONE
50'
SHALE
SHALE
FLOOR CLAY
FLOOR CLAY

FIG. 21—Diagrammatic sketch, indicating probable original conditions, movements, and results, in the formation of the channel sandstones ("faults") of Peoria County. See text for explanation.

"fault." If this is a purely glacial phenomenon related to ice shove, as proposed by Udden, then the delineation of areas where such a phenomenon is to be found becomes very difficult. But if on the other hand the disturbance can be traced to the existence of a channel sandstone, it becomes a matter of reasonable possibility to locate the position and trend of such a deposit. Without examining the "channel sandstone" interpretation at length, two points may well be mentioned here in its support, the first very briefly, but the second in somewhat more detail and with a map because of its weight and its practical application to the "fault" problem.

1. The pressures and strains developed by differential settling of the magnitude assumed, would seem to be entirely adequate to the production of the features now observed at the "faults."

2. As a result of the past ten years' investigation, drilling, and mine operations, engineers and operators have analyzed the "faults" as masses of sandstone penetrating below the horizon of the coal and have blocked out their extent over an area sufficient to indicate that they have the general alignment of stream channels.

The position of the channel sandstones over the whole of the Peoria region is not very definitely known. Many of the mines south of Peoria and those in Tazewell County near East Peoria have felt out the edge of the "faults" so that some idea of the position of one of the sandstones is available. South of Peoria the Leitner Coal Company's mine, and the Walben mine, M. E. Case Coal Company have worked up to the edge of the sandstone. The Wolschlag mine is reported to lie immediately to the east of the "fault." Numerous drill holes to test the coal have penetrated the sandstone in the area lying between the east branch of Lamarsh Creek and the Illinois. Additional drilling has been recently completed west of the east branch of Lamarsh Creek. The area of coal affected by the sandstone seems to be confined to a strip of territory lying along the east side of the valley of the east branch of Lamarsh Creek and extending south of Lamarsh Creek along the bluff of the Illinois as far as Mapleton. A similar area where the sandstone cuts out the coal is reported in the vicinity of Wesley in Tazewell County.

The accompanying map (fig. 22) shows the status of information concerning the position of the channel sandstone south of Peoria and in Hollis and Limestone townships as worked out largely by Mr. W. C. Evans of Peoria by drilling and observation in mines.

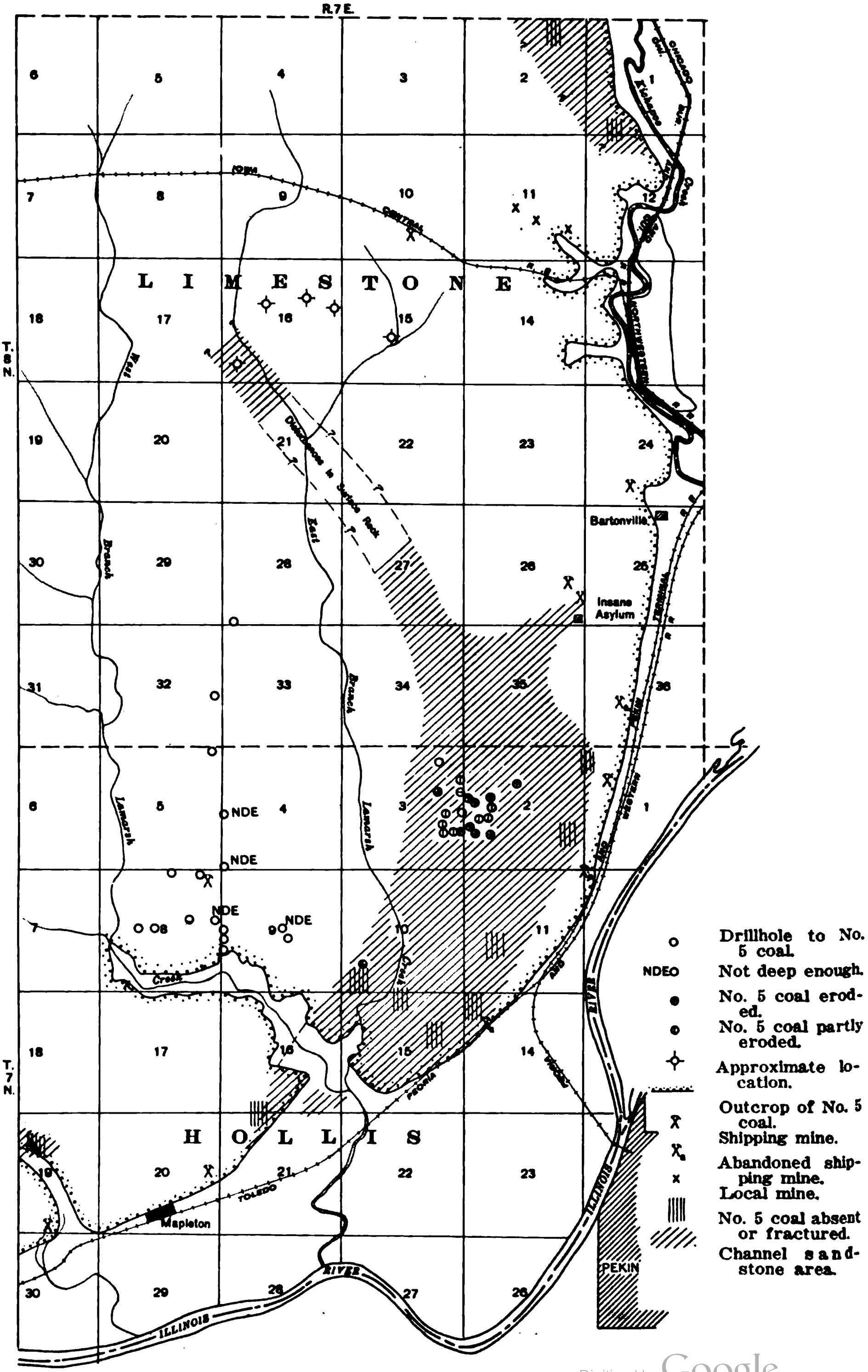

FIG. 22.—Map showing the position of the channel sandstone south of Peoria.

With the meager reports that are in existence concerning the succession of strata in the part of Peoria County outside of the Peoria quadrangle it is impossible to say that there are no other areas of channel sandstone in the county, penetrating the horizon of No. 5 coal. None of the mines located at Hanna, Glassford, or Kramms reports such "faults" in the area under operation. However, exploration of undeveloped coal land should be guided by the possibility of such an irregularity being present.

NO. 6 COAL

No. 6 coal lies in two benches, separated by a layer of clay known as the "blue band." Part of Udden's description[1] of this coal is cited herewith:

> "The lower bench varies from 1 foot 3 inches to 1 foot 8 inches thick. The 'clay band' as the 'blue band' is also called by the miners, is uniform and persistent, being absent in a few places, and is 2 to 3 inches thick. The upper bench of the coal is in many places partly destroyed. * * * Where intact, it measures 2 feet 1 inch to 2 feet 6 inches thick. In addition to this there is in places about 6 inches of bony coal, which was probably only locally deposited. * * * In places the lower part of the coal has two interrupted bands of marcasite, one about 5 inches from the bottom and the other 9 inches higher up. These measure one-fourth to one-half inch thick."

Field investigations, drilling, and some mining of this bed demonstrate that No. 6 coal is more uncertain in its distribution than No. 5. The seam varies greatly in thickness and in places seems to be entirely missing. The cause of its irregular distribution seems to be erosion subsequent to deposition rather than failure of deposition. In the case of No. 5 coal, the removal of the peat and absence of the coal was along rather well-defined lines of what were apparently the courses of stream channels. But the removal of No. 6 coal was seemingly along less definitely organized lines suggesting that possibly the irregularities in the coal are actually inheritances of irregularities in the original bog in the low parts of which there may have been open-water ponds and sluggish streams, these channels and ponds being ultimately filled with silt and sand. These conditions of deposition seem to have persisted over the entire area in which No. 6 coal was deposited in the State. The coal seems to have been more commonly affected by the irregularities in this region than in some parts of the State, but the general nature of the irregularities seems to be everywhere the same.

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[1] Op. cit., p. 33.

MC LEANSBORO FORMATION

STRATA BETWEEN NO. 6 AND NO. 7 COALS.

In Peoria County the strata composing the McLeansboro formation include all the rocks between the drift and No. 6 coal. No. 7 coal, one of the widespread coal beds of the State, which in the Danville and Longwall districts is of workable thickness, occurs 25 to 30 feet above the base of the formation, but in this district is nowhere of commercial thickness.

The strata overlying No. 6 coal vary considerably. The normal succession, occurring where the entire section is present, consists of a gray shale, in places dark gray, 18 inches to 2 feet thick, overlain by limestone averaging a little more than 2 feet and in sixteen measurements, according to Udden, ranging from 3 inches to 4 feet. In many places the shale above the coal is replaced by a variable sandy deposit known among the miners as "white top." Udden expresses the opinion that this deposit is of much later age than the strata it replaces or between which it is inclosed and suggests that it originated as cave wash in solution cavities located in the under part of the limestone cap-rock, erosion in which also affected the upper part of the coal bed.[1] The present writer, on the other hand, is of the opinion that the sandy shale composing the "white top" represents deposits in depressions in the original peat bog. It is believed that the lack of well-defined bedding in these deposits and the presence of slickensided surfaces and partings and the conchoidal fracture of the material which Udden cites as evidence of the "cave" origin, were produced as a result of the "kneading" to which the deposits were subjected because of the differential shrinkage of areas of the peat of considerably different thickness. The shrinkage of a bed of peat to coal now about 4 feet thick would be in some proportion ranging between 32 to 1 and 3 to 1, 5 to 1 being apparently the approximate average proportion that holds for Illinois coals. It is clear that if the coal in places is 4 feet thick and in other places because of the presence of a lenticular body of shale embedded in its upper part only half as thick or less, movement must have taken place to adjust the strains that resulted from differential shrinkage of the thick and thin peat. As a result of the readjustments that must take place in the lens of sandy shale or "white top" this material will be "kneaded" and fractured and will tend to lose much if not all of its originally laminated structure. The material will accordingly furnish a very treacherous roof because of lack of coherence. Not uncommonly the strains are carried downward into the coal, fracturing and displacing it, especially along the edge of the "white top" masses.

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[1] Op. cit., pp. 84-85.

The cap-rock of No. 6 coal is fairly continuous, apparently even more continuous than the coal itself. The rock is an impure argillaceous limestone, the lime content of which does not appear to comprise much more than half the rock. It does not have the appearance of a rock that would develop large cavities by the action of ground water. Udden[1] describes the rock as follows:

> "Clay seams separate it into four or five beds of unequal thickness. In places the middle beds weather into blocks a foot and a half thick. The thin top layer is in places separated from the other beds by a seam of clay measuring several inches.
>
> "The rock is light gray in color. In places it exhibits an indistinct nodular or concretionary structure, the nodules measuring one-half to one inch in diameter, but this is not general. With the aid of a lens nearly one-third of the mass of the upper beds is seen to consist of organic fragments, representing mostly brachiopods, crinoids, and *Fusulinas*. These lie embedded in an apparently structureless calcareous matrix. Many of the shell fragments are appreciably rounded. Fragments of *Fusulina* can be found in every piece of rock. Another constant characteristic is the presence, especially in the upper beds, of black nodular lumps impregnated with bituminous material. They are sharply delineated from the matrix and exhibit a rough exterior surface. In many places they contain fragments of shells and appear to conform to the structure of the limestone itself. In size they vary from a mere speck to masses 2 inches in diameter. Generally they are three-fourths of an inch in diameter and slightly flattened. In the upper beds there are in places rounded pieces of calamarian stems, which are also black from impregnating bituminous material and exhibit a coarse cellular tissue."

In Illinois the fossil *Fusulina* (now known as *Girtyina*) mentioned in the foregoing quotation is apparently restricted in its occurrence to the limestone cap-rock of No. 6 coal and to a limestone supposed to occur several hundred feet above No. 6 coal and found only in the eastern part of the State. The fossil has somewhat the appearance of a short thick oat grain. Because it is almost invariably present in every piece of the rock down to the size of a walnut and is rather readily found, it serves as an accurate and practical method of identifying this limestone and the coal a short distance beneath it.

Above the limestone is light-gray or greenish shale or "soapstone" above which is a massive sandstone, but which ranges in thickness from 10 to 25 feet but averages about 20 feet. Between the sandstone and the fire clay of No. 7 coal is generally clay shale 1 to 8 feet thick. In some places this is dark greenish gray, and in others dark red or brown. This red clay Udden regards as an infallible guiding stratum for the coal beds of this region. Where present, it lies from 8 to 16 feet under coal bed No. 7 and no other red clay is exposed in the Pennsylvanian system in the Peoria region. It is noteworthy that a bed of variegated shales is also reported to be present in District VII[1] within 50 feet above No. 6 coal. As a rule in that area they lie a short distance above No. 7 coal.

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[1] Op. cit., p. 34.

NO. 7 COAL

No. 7 coal is generally present in the county except where it has been removed by erosion. It maintains a very uniform thickness of about 18 inches, which is insufficient to make the coal of commercial value, at least for many years.

Udden states that the coal is especially characterized by lenses of mineral charcoal commonly found near the top of the bed. In places the charcoal is impregnated with pyrite and appears as "sulphur cakes" or "blackjack."

STRATA ABOVE NO. 7 COAL

The roof of No. 7 coal consists of a few inches of gray soft shale resting upon the coal and above this, black shale in varying thickness from 6 inches to 2 feet. In some places the black shale rests directly upon the coal. Above the black shale there are in most places a few feet of slightly siliceous and micaceous shale. The overlying sandstone rests upon an uneven surface of sufficient relief to entirely eliminate the upper shale in many places so that it rests upon the underlying black shale and even upon the gray clay below. The sandstone varies in texture from sandy shale to sandstone. Generally the lower beds are coarser. Udden states[2] that about a mile west of Bartonville this sandstone is nearly 40 feet thick.

At the top of these sandy beds is about 6½ feet of dark shale, part of which is thought by Udden to represent an old soil. This is followed by a 20-foot limestone ledge, known as the Lonsdale limestone from its exposure at the old Lonsdale quarries. "The lower 5 feet of this rock consists of a firmly cemented largely organic limestone, in beds varying in thickness from 6 inches to 1½ feet." In places part of the rock consists "of a calcareous mud-lump breccia, in which regular lumps of a dark compact structureless carbonate of lime are embedded in a less pure, greenish-gray matrix. In this matrix fragments of fossils also occur." Above these firm beds there are 15 feet of a slightly argillaceous and more flaggy rock, in which concretionary structure can nearly always be detected.[3]

Above the limestone is a 15-foot sandstone which has only a limited distribution as has also the overlying dark shale, which is the uppermost Pennsylvanian stratum in the Peoria quadrangle. The general dip of the rocks toward the southeast makes it probable that the youngest "Coal Measures" rocks will be found in the southeast part of the county.

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[1] Kay, F. H., Coal Resources of District VII: Illinois Coal Mining Investigations Bull. 11, p. 24, 1915.

[2] U. S. Geol. Survey Bull. 506, p. 38.

[3] Op. cit., p. 40.

DEPOSITS ABOVE THE COAL-BEARING ROCKS

The material overlying the Pennsylvanian strata consists either of alluvium or glacial drift, that is unconsolidated stony clay, and sand and gravel. Because the bed-rock surface was a land surface before glaciation, except for a relatively thin covering of soil and of alluvium along streams, it was affected by the ordinary processes of stream action which produced the usual organized lines of drainage with divides separating them. The glacial drift left by the continental ice sheet tended to cover up the inequalities in the surface overridden by the ice, and to produce a new surface with a relief originating in the unequal distribution and thickness of the drift. The drift has a bearing on mining operations because it conceals the form of the underlying rock surface and the character of the outcropping rocks, and renders the distribution a single stratum, such as a coal bed, difficult to determine without drilling.

The alluvium is confined to the valleys. The river which occupied the valley of the Illinois before glacial time flowed at a much lower level and at a position slightly different from that of the present river. The map of the pre-glacial surface (Pl. VI) shows the position of the pre-glacial valley and the altitude of the channel. It will be noted that the deepest part of this valley had an altitude of about 350 feet above sea level. As No. 2 coal lies at an altitude of about 300 feet in the vicinity of Orchard Mines and Pekin, it follows that this coal is probably very lightly covered with drift if not removed within the pre-glacial Illinois valley in the southern part of the county. What is possibly this coal is reported to outcrop below the valley fill beneath the bed of the river about opposite Kingston Mines.[1]

The wide area of deep filling at Peoria and up Kickapoo Creek and a similar area of thick drift across the Illinois in Fondulac Township, Tazewell County, and the general slopes of the old pre-glacial upland surface in Kickapoo, Limestone, and Hollis townships and in Groveland Township, Tazewell County, suggest to Udden[2] the possibility that the old upland was continuous across the valley at the position of present narrows between Bartonville and Hollis. This upland in that case would represent a divide between a stream crossing the course of the present Illinois in a northwest-southeast direction at about the position of Peoria and Kickapoo Creek and another stream farther south. Udden, however, presents another hypothesis to account for the narrows. "If the Illinois River valley antedates the glacial epoch, its narrow course between Iowa Junction and Pekin may be due to the comparatively more resistant sandstone above coal bed No. 5 which prevented as rapid recession of the bluffs on both sides of the valley as has taken place elsewhere."

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[1] Cooley, Lyman E., The Illinois River; physical relations and removal of the navigation dams: Sanitary District of Chicago, Chart opposite page 42, 1914.

[2] U. S. Geol. Survey Bull. 506, p. 52.

The character and position of the pre-glacial valleys in Peoria County that may exist outside of the area of the Peoria quadrangle have not been reported.

Outcrops along the west bluff of the Illinois are nearly continuous southward from Kickapoo Creek, and northward from Senachwine Creek at Chillicothe. Between Peoria and Chillicothe, however, the bluffs are composed of glacial till, representing remnants of the filling in the pre-glacial Illinois valley.

THE MINABLE COAL OF PEORIA COUNTY

Udden states that no less than seven coal beds occur in the Pennsylvanian rocks of the Peoria region, of which only three are exposed. Of these seven, but four have commercial value, and of these four only three have been operated during the last calendar year. The beds of workable thickness are No. 1, No. 2, No. 5, No. 6, and No. 7. Of these only No. 5 is worked extensively on a commercial scale. One commercial mine has reopened workings in No. 2 coal, and several wagon mines operating No. 6 and No. 7 coal. The general character of these coals has been described in the section devoted to the geological succession in Peoria County. It remains to consider the coals from an economic viewpoint and to review the factors that affect its commercial value. These are distribution, thickness, chemical character of the coal, nature of impurities and irregularities, and character of roof and floor. The coals will be described in an order the reverse of that just used in discussion of the strata of the Pennsylvanian system.

NO. 7 COAL

No. 7 coal is not of workable thickness in the central and southern part of the county. Udden[1] states that the coal averages 1 foot 5 inches in the Peoria quadrangle, and that the uniformity of its thickness is remarkable in that area. Worthen[2] states in regard to this coal that:

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[1] Udden, J. A., Geology and mineral resources of the Peoria quadrangle: U. S. Geological Survey Bull. 506, p.36, 1912.

[2] Worthen, A. H., Geological Survey of Illinois, Vol. 5, p. 249, 1873.

"In the northern portion of the county, No. 7 is the principal coal outcropping above the valleys of the streams, and the lower seams can only be reached by shafts, or by an inclined tunnel carried down to their level. This seam ranges from two and a half to three feet in thickness in this part of the county, and its outcrop may be found on most of the small streams. It is very regular in its development, and affords a coal of fair quality where it is mined beyond the influence of atmospheric agencies."

The thickening of No. 7 coal northward in the northern part of the county and thence toward the Longwall District parallels a thinning of No. 6 coal in the same direction. In the northern district No. 6 coal is apparently absent, whereas No. 7 has a thickness of between 4 and 5 feet. In northeastern Peoria County north of Chillicothe, No. 7 coal has been worked at a number of wagon mines. In this vicinity the coal is about three feet thick. The Survey has little definite information in regard to the area underlain by No. 7 coal of workable thickness, or of the general mining conditions.

MINE NOTES, NO. 7 COAL

The following notes taken in Crew Brothers' mine north of Chillicothe in 1909 are given in lieu of more adequate data.

CREW BROTHERS' LOCAL MINE, NEAR CHILLICOTHE

Entrance: Drift; No. 7 coal.

Thickness of coal: Varies from 2 feet to 3½ feet; averages 3 feet.

Section of the coal:

Section of No. 7 coal in Crew Brothers' mine, near Chillicothe

	Thickness	
	Ft.	*in.*
Roof: Black slate, or soapstone	..	..
Coal	..	10¾
Trace of clay	..	..
Coal	..	6½
Trace of clay	..	..
Coal	..	6
Parting	..	..
Coal	..	7¼
Mother coal and trace of pyrite	..	1
Coal	..	4
Floor: Fire clay	..	..
	2	11½

Character of the coal: The seam is fairly uniform throughout. The bottom coal, below the mother coal, and the coal just above the mother coal are somewhat harder than the other benches. The trace of pyrite in the mother coal is persistent throughout the mine. It was called the "blue band," but is not to be confused with the well-known "blue band" so characteristic of No. 6 coal.

Character of the roof and floor: The roof is a black shale or "slate" which is in places replaced by "soapstone." There was no limestone present as a cap-rock. The floor is fire clay.

NO. 6 COAL

As No. 6 coal lies at an altitude of about 550 feet in the Peoria region, it is consequently above the level of the Illinois and of Kickapoo Creek for a considerable distance above the mouth of the Kickapoo. In western Peoria County at Elmwood No. 6 coal is below stream level and has an altitude of about 575 to 600 feet. It has about the same altitude at Princeville. It is apparent that most of the county is underlain by this coal, that it is generally under sufficient cover and with roof undisturbed, so as to be accessible for drift mining in many places, especially along Kickapoo Creek.

The coal possesses certain characteristics which stand in the way of its general exploitation. It is more irregular in its development than any of the other coals and principally for this reason it is generally neglected. Worthen states in regard to this coal that "When fully developed it is quite as thick as No. 5, but the miner who commences drifting into this coal on a promising outcrop from four to five feet in thickness, will frequently, in a distance of a hundred yards or less, find the coal gradually thinning out to one-half its original thickness."[1] Apparently the coal is more persistently developed in workable thickness in the northwestern part of the county than in the southern or eastern part. Along the Illinois valley northward from Chillicothe it seems to be thinner than No. 7 and has not been much worked.

Roof conditions also present difficulties in the working of the coal that are not easily overcome. The regular normal roof is shale, commonly gray, but in places nearly black, 6 inches to possibly 3 feet thick, above which is a persistent cap-rock, averaging about 2 feet thick in the Peoria quadrangle but ranging from 3 inches to 4 feet. It is possibly considerably thicker in some places in the northern part of the county. Notes taken about ten years ago in a mine located near Brimfield state that 25 to 30 feet of limestone are present in that locality. Under normal roof condition no serious difficulties are encountered. The roof shale, which is commonly a foot or less in thickness, usually falls soon after the coal is extracted, leaving a good hard limestone roof. The expense of removing the shale is considerable, of course, but the cost of its removal can be fairly well estimated, so that it can be anticipated before a project is started. The usual roof, however, is in many places replaced by "white top," the nature and possible cause of which were discussed on an earlier page. It is sufficient to restate here that this material appears to be the sand and sandy mud filling of depressions existing in the original peat swamp, later covered along with the rest of the area, by the limestone cap-rock. Adjustments that were necessary because of the differential shrinkage during the change of the peat and sands to coal and rock destroyed the original structure of the sandy lens, "kneading" and crushing them until they now lack coherence and are very difficult to hold. Moreover, the adjustments commonly produced fractures in the coal and weakened the overlying limestone. The total result is a roof condition generally above thin coal that is extremely undesirable, as it is dangerous and costly to provide for. No system of distribution of the "white top" has been discovered. It is usually present to some extent in any body of coal large enough to be worked, and mines have been worked until the poor roof conditions exist in half or more of the workings. Profitable mining is impossible, however, under these conditions.

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[1] Worthen, A. H., Geological Survey of Illinois, Vol. 5, pp. 249-250. 1873.

It is apparent that commercial exploitation of No. 6 coal in this region is not to be considered while No. 5 coal is present in large blocks suitable for mining. It is possible that some system more suitable for operating the No. 6 coal than the room-and-pillar method can be employed, designed to meet the uncertainties that exist, and it is possible also that careful investigation of white top in the region may reveal some system of distribution the discovery of which will assist in devising a suitable method for the extraction of the good coal. At present no block of this coal should be considered for development without intensive drilling to determine the roof conditions and the thickness of the coal.

No. 6 coal is characteristically divided into beds or benches wherever it occurs in the State. Partings and seams of clay, mother coal, or pyrite are generally present and in this county apparently always present to subdivide the bed into benches. Udden describes the bed as subdivided into only two benches by the clay seam or "blue band," a seam of clay or shale ½ to 3 inches thick, found 12 to 14 inches from the bottom and 33 to 46 inches from the top of the coal. Where the white top is present more or less of the upper bench is absent, so that the thickness of this bench varies considerably. As a general thing it is believed that the bottom bench is undisturbed. Observations in various local mines indicate that bedded impurities other than the clay or blue band are very persistent at least locally. A rather continuous band of "sulphur" of clay lies in the lower bench generally in the upper half. It is not always possible to identify blue band with certainty where both of these bands are present, as they are commonly quite similar. The upper bench, above the blue band, commonly contains several thin partings. One, 12 to 18 inches from the top, seems to be fairly persistent in the mines in the northern part of the county, others are of local distribution, not being persistent even throughout the workings of a single small mine. The total effect of these various impurities is to make the coal as produced rather dirty, although the individual benches between the partings are clean coal. The task of mining clean coal by carefully separating the dirt from the coal in the mine is rather exacting upon the miner and it is doubtful whether it can generally be effectively accomplished. Mechanical separation by washing or other means would probably produce much cleaner coal than the usual mine-run output.

The occurrence of pyrite ("sulphur") in bands and thin lenses is characteristic of No. 6 coal nearly everywhere in the State except in the area of low-sulphur coal in southern Illinois. This sheet or plate pyrite is commonly of either a bright or a stony dull variety, compact and structureless. As its separation from the coal is comparatively easy, this coal is more readily cleaned of its sulphur than other beds in which lenticular laminated gray or brown pyrite is found. The fact that the pyrite commonly occurs in the partings makes it all the more readily extracted at the face.

Observations in a few of the local banks indicate that this coal like No. 5 is cut by clay veins or horsebacks. They are not so common, however, as to be typical of the bed, and do not represent a serious impurity in the coal as is commonly the case in No. 5.

The floor of this coal is fire clay, with no peculiar characteristics so far as is known.

MINE NOTES, NO. 6 COAL

The following observations were made in a few mines in the county operating No. 6 coal. Some have since been abandoned and all were local operations at the time the observations were made.

BERRY BROTHERS' WAGON MINE, NEAR BRIMFIELD
IN THE SW. ¼, NW. ¼, SEC. 5, T. 10 N., R. 6 E.

Entrance: Shaft; depth to No. 6 coal about 35 feet.

Thickness of coal: Varies from 2 feet to 4 feet 9 inches; averages 3 feet 3 inches.

Section of the coal:

Section of No. 6 coal, Berry Brothers' mine, near Brimfield

	Thickness	
	Ft.	*in.*
Coal (top coal)	1	6
Pyrite	..	½
Coal	1	..
Clay band ("blue band")	..	2
Coal	1	..
Pyrite	..	½
Coal	1	..
	4	9

The best coal in the above section is the upper 30 inches. The two bands of pyrite noted are persistent throughout the workings.

Character of the coal: The general succession is indicated by the above generalized section. Clay slips or "horsebacks" are common and there is considerable "white top" present. The coal dips to the northeast about 1 per cent, and one small fault with 2½ feet displacement was noted.

Character of the roof: The normal roof is gray to black shale which falls with the coal, with a limestone cap-rock above. The small fossil Girtyina was identified in fragments of this rock, which establishes the identity of the coal.

Character of the floor: The floor is described as fire clay. No unusual characteristics were noted.

TAYLOR AND SONS' WAGON MINE AT PRINCEVILLE,
NW. ¼, NW. ¼, SEC. 24, T. 11 N., R. 6 E.

Entrance: Shaft; depth to No. 6 coal about 75 feet.

Thickness of coal: Varies from 2 feet to 5 feet 2 inches; averages 4 feet 8 inches.

Sections of the coal:

Section of No. 6 coal in Taylor and Sons' local mine at Princeville
1st room off 1st west entry, 500 feet from shaft

		Thickness	
		Ft.	*in*
1.	Coal	..	2½
2.	Parting	..	..
3.	Coal	..	10
4.	Clay parting	..	⅛
5.	Coal	..	¼
6.	Clay	..	⅛
7.	Coal	..	10
8.	Pyrite	..	¼
9.	Coal	..	4½
10.	Clay	..	¼
11.	Coal	..	6¾
12.	Clay ("blue band," called clay band)	..	2¼
13.	Pyrite	..	½
14.	Coal	..	7
15.	Clay (called "blue band")	..	½
16.	Coal	..	6
17.	Pyrite	..	½
18.	Coal	..	7
		4	10½

Character of the coal: Of the partings noted in the preceding section of the coal, numbers 4, 8, 12, 15 and 17 are persistent. As the section indicates, the coal is rather dirty because of the numerous bands of impurity. The coal between the bands, however, is clean.

Character of the roof: The immediate roof is a black to gray carbonaceous shale spoken of as "ramble." This is about 6 inches thick and above it is the limestone cap-rock. The shale falls with the withdrawal of the coal, leaving a firm hard limestone roof. No record is made of the presence of "white top" in this mine.

Character of the floor: An impure coal composed of a mixture of mother coal and shale commonly is present in the bottom of the bed to a thickness of 6 inches or less. Below this material fire clay is reported to be present.

WAGON MINE, LOCATED BETWEEN GLASFORD AND HANNA, SW. ¼ SE. ¼ NE. ¼, SEC. 34, T. 8 N., R. 6 E.

Entrance: Drift; No. 6 coal.
Thickness of coal: Average 3 feet 10 inches.
Section of coal:

Section of coal in local mine, north of Glasford

	Thickness	
	Ft.	*in.*
Limestone with many *Girtyina*....................3 feet to	4	..
Shale, gray ....4 inches to	..	8
Coal	2	..
Blue band.......................1½ to 3 inches, average	..	1
Coal	..	3
Pyrite lenses ....up to	..	3
Coal	..	5
Clay band ....¼ inch to	..	½
Coal	..	9½
Fire clay	..	..
	3	10

NO. 5 COAL

No. 5 coal is the most valuable bed in the county. Its desirability rests upon its fairly widespread occurrence, its uniform thickness, the satisfactory mining conditions under which much of it can be worked, and the absence of impurities that can not be removed by careful mining. In places, however, conditions exist that render the cost of mining prohibitive of profit, or that affect the quality of the coal in such a way as to render it unmarketable. These conditions are local, however, being far from common enough to condemn the whole body of coal.

Conditions which affect the distribution of the coal have already been described at some length earlier in this bulletin, in the discussion of the strata between No. 5 and No. 7 coals. The attention of the reader who is especially interested in the irregularities in the distribution of the coal is therefore directed to the discussion on pages 161 to 163, and 165 to 175. It may be repeated here that uncertainties with respect to the distribution of the coal that are of significance in the development of new properties are of two sorts. One results from the lack of definite information with regard to the position and depth of lines of pre-glacial drainage, and the other from the undetermined extent and distribution of certain bodies of sandstone, which have been termed channel sandstones, and which lie across the position of No. 5 coal.

Udden states that the average thickness of No. 5 coal is 4 feet 4 inches for the Peoria quadrangle. This is probably a fairly accurate estimate for the entire county, although no figures are available concerning the thickness of this coal in the northern part where No. 6 rather than No. 5 coal is being mined at local banks. The coal shows a variation in thickness of not over 5 to 6 inches in each area where it is worked. In the places where it departs from the usual thickness, the bed more commonly tends to be thinner rather than thicker than the average. The more common variations in thickness, however, are apparent rather than real, being due to small faults accompanied by a slight displacement at the position of the clay slips or horsebacks. When the plane of movement is inclined, the result is to produce an apparent thinning of the bed when measured vertically across the fault plane (fig. 23). Such slight displacements at horsebacks are the most frequent cause of variations in thickness of the No. 5 coal.

The irregularities in No. 5 coal that are the most continual source of difficulty and expense are the horsebacks, both clay slips and "sulphur spars." The number of these differs considerably in different parts of the county, some mines encountering them in great numbers, whereas other mines find so few that they are of little consequence. The mines in Hollis and Limestone townships, except those west of Mapleton, seem to be more troubled by the horsebacks than those farther west at Glasford, Hanna, and Edwards.

The Peoria County horsebacks are similar to those described in Fulton County and to those that occur elsewhere in this district. At least for a short distance above the coal the coal bed and overlying strata have been fractured and in some instances offset along the fracture. The planes of fracture are generally nearly vertical and rarely if ever inclined more than 45 degrees. Opposite sides of the fractures, along which there has been no movement to offset the bed, are roughly parallel. The fractures themselves have been filled with clay, which apparently has been forced into them, or with vein pyrite where they are very narrow. The upper layers of the coal next to the fractures that are clay filled have commonly been forced downward, and fragments of roof shale are found in the fissures below the top of the coal, indicating that the clay has been forced in from above. This relationship possibly does not always hold and possibly is of no great significance, for whether the clay originated below or above the coal it obviously is forced into the fissures in the coal as an adjustment of inequalities in pressure which probably are responsible for the fracturing.

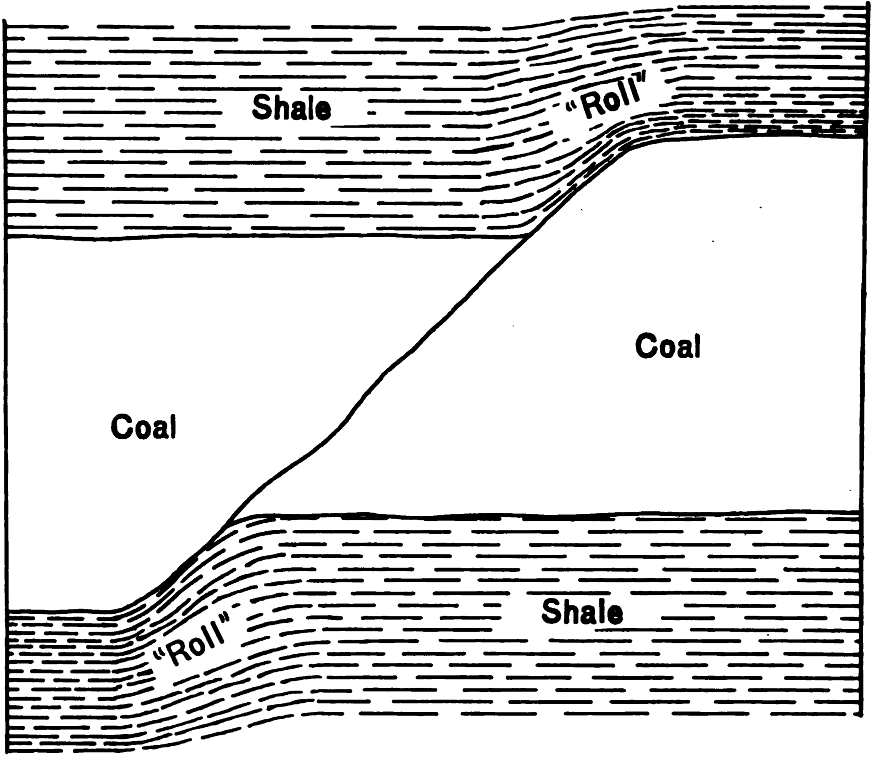

FIG. 23.—Diagrammatic sketch showing the manner in which faulting along a horseback will effect an apparent thinning of the coal bed.

Where these horsebacks are present, production of clean coal and the support of the roof near the fractures are difficult. The first difficulty is met by discarding all the coal affected by the horseback. The clay veins are generally rather heavily impregnated with pyrite which also fills many of the smaller cracks in the coal adjacent to the main fissure, so that the horseback and some attached coal on either side is usually removed in large pieces. The expense of removing the horsebacks is indicated by the following agreement between the operators and miners of the Second Sub-District, dated April 1, 1918:

> "Eighteen—That all horsebacks, rolls, or slips, marking the coal two to six inches average width in the center of such horseback, roll, or slip, whether coming from top or bottom, shall be $2.80, and 23 cents for each additional inch thereafter.
>
> "When a slip, roll, or horseback continues with the working place more than the width of such working place, it shall be paid for at the same rate, as long as it continues with the said working place."

The coal removed and wasted by this method of handling the horsebacks amounts to a very considerable proportion of the coal mined in some operations.

The second difficulty noted above, that of supporting the roof near horsebacks, is a very serious one. If the cracks are numerous and rather wide, so that the cohesion of the cap-rock is weakened, the strata are almost impossible to hold. Horsebacks that run with an entry not uncommonly cause "falls" their entire length of many feet. Such conditions of course make the expense of mining very high. There is apparently no systematic attempt in any of the mines to remedy the conditions. They are met as they arise and the success or failure of a mining enterprise depends largely upon the company's fortune in striking a good or bad piece of coal. Unfortunately drilling does not assist much in determining the frequency of the horsebacks. The prospector for new resources is dependent upon information gained at outcrops, in local banks, and in mines adjacent to the property under consideration.

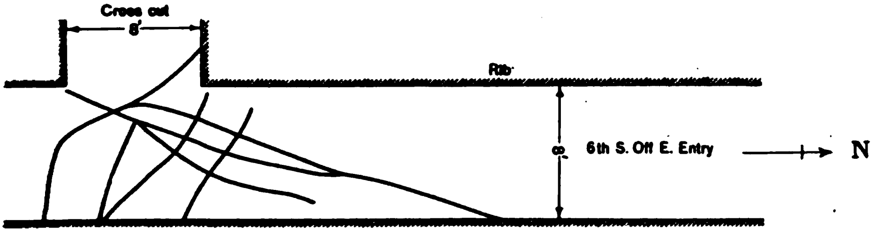

FIG. 24.—Sketch showing the cracks cutting the roof along the 6th southeast entry of the Leitner Coal Company's mine.

The accompanying sketch (fig. 24) of the cracks cutting the roof along one entry of the Leitner Coal Company's mine will give some idea of the frequency of the horsebacks in some mines in the region.

The "sulphur spars" are nearly as expensive and possibly more troublesome to handle than the clay veins. The pyrite is true vein filling which not only occupies the space opened by the fissure but ramifies the adjacent coal along small cracks and cleavage planes. The result is a mass of hard coal commonly extending as much as four inches either side of the main vein. This material is exceedingly hard to cut and is more objectionable to the miner than the clay veins, although the latter are larger.

"Sulphur" or pyrite other than that found in the sulphur spars is an impurity of varying importance. In some mines it is very common and its removal a matter of considerable difficulty. In other mines it is of small consequence. In general the sulphur is more common in those mines in which the coal bed is crossed by numerous horsebacks. The pyrite is principally of two kinds: the bright brassy variety commonly found near the roof or in the upper part of the coal; and the brown or gray pyrite lenses. The former is present in about the same amount in all the mines irrespective of the number of horsebacks present; the latter is distributed in greater abundance near horsebacks, and especially near the clay veins. The gray or brown sulphur occurs as lenticular masses with indistinct outline and grayish color, and apparently consists of interlaminated pyrite and carbonaceous material. Many of the gray pyrite lenses widen out toward a contiguous clay vein, attaining their greatest size at the contact. The lenses are not uncommonly 4 inches thick at the thickest part and extend laterally as much as 3 or 4 feet. This material is supposed to be rejected by the miner, a docking system being in force to encourage the loading of clean coal. The laminated pyrite seems to have an origin dependent in some manner upon the fissuring and therefore constitutes additional difficulty with which the mines having numerous horsebacks must contend. In themselves, however, they are not a very serious impurity, and do not greatly affect the value of the coal.

Some of the mines, in addition to the varieties of pyrite already described, have a streak or thin lens of pyrite from one-eighth to one inch thick and about half an inch above the bottom of the coal. This sulphur comes up with the bottom coal and is then broken off, together with more or less attached coal. Not uncommonly, likewise, the lens or mass of limestone lying between the coal and the "slate" and carrying many fossils is generally replaced to considerable extent by pyrite so that the fossils and texture of the rock are preserved in pyrite rather than limestone. The "niggerheads" in the black "slate" are also pyritized, though commonly only in a zone at the surface. In some of the mines south of Peoria a discontinuous layer of "brown" pyrite is present about midway in the bed.

The typical roof of No. 5 coal in this county as elsewhere is a succession of black "slate" about 1 foot thick, above which is about 12 inches of gray clay or clod, and 8 to 12 inches of cap-rock. The thickness of the cap-rock may vary considerably from this figure, but as it usually stays up, its general thickness is not accurately determinable. Except where broken by fissures the roof is very satisfactory.

Over part of the coal is a massive, substantial sandstone roof. This roof is most commonly found near the "faults" or channel deposits that have been described. The coal is not essentially different under the sandstone from what it is under the shale. Under each variety of cover it has the usual horsebacks and other irregularities, the fissures continuing up into the roof whether it be sandstone or shale.

The floor is a fire clay of the usual character and gives no special difficulties.

MINE NOTES, NO. 5 COAL

The following observations are presented with the idea that they will throw light on conditions in local areas in the field.

LOGAN COAL COMPANY'S NO. 1 MINE AT HANNA CITY

Entrance: Shaft; about 236 feet to No. 5 coal.
Thickness: About 3 feet 4 inches.
Sections of the coal:[1]

Sections of coal bed in Hanna City mine

Section	A		B		C		D	
Laboratory No.	22982		22983		22984		22985	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
Roof, shale 2½ feet	..	..	..	..	..	..	..	..
Coal, bony	..	6*	..	..	..	..	..	6*
Coal, bright	1	6	1	0	3	3	1	0
"Sulphur" to "mother coal"	Streak		..	¼*	..	..	Streak	
Coal, hard	1	4	2	3¾	..	..	1	10
Floor, underclay	..	..	..	..	..	..	..	..
Thickness of bed	3	4	3	4	3	3	3	4
Thickness of coal sampled	2	10	3	3¾	3	3	2	10

*Not included in sample.

Character of the roof and floor: Roof is a hard gray shale about 2 feet 6 inches thick; the floor is underclay 3 to 5 feet thick.

Samples were collected at the places where the sections were made and analyzed by the U. S. Bureau of Mines,[2] and the results are reprinted as a part of Table 3 of this report.

CLARK COAL AND COKE COMPANY'S EMPIRE (NO. 2) MINE AT PEORIA

Entrance: Shaft; depth to No. 5 coal, 180 feet.
Thickness of coal: Varies from 3 to 4½ feet; average 4 feet.
Sections of the coal:

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[1] U. S. Bureau of Mines Bull. 123, p. 179.
[2] U. S. Bureau of Mines Bull. 123, p. 35.

Empire Mine

Sections of No. 5 coal in the Clark Coal and Coke Company's

Section 1—First butt entry off 11th east entry

	Thickness	
	Ft.	*in.*
Coal	..	7½
Soot seam	..	..
Coal	..	11½
Soot seam	1	10
Coal	..	8½
	4	1½

Section 2—Face 13th entry off main south entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean	..	11
Mother coal parting	..	⅛
Coal, clean	..	3
Mother coal	..	⅛
Coal, fairly clean	2	¾
Floor: Fire clay	..	..
	3	3

Impurities: Pyrite in vertical streaks and a few horizontal streaks of mother coal.

Section 3—Room 3, 7th south entry off 11th west off straight south

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, fairly clean	3	5
Bone	..	⅝
Coal, clean	..	1¼
Bone	..	⅝
Coal, clean	..	5½
Floor: Shell coal and fire clay	..	..
	4	1

Impurities: Bone and mother coal in horizontal streaks; calcite in vertical streaks.

Section 4—Face, 3d north entry off 1st west off straight south

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, bright	1	1¾
Mother coal	..	¼
Coal, fairly clean, slightly streaked	..	11½
"Sulphur"	..	½
Coal, fairly clean	1	½
Bone, lens	..	½
Coal, fairly clean	..	11
Floor: Fire clay	..	..
	4	2

Impurities: Calcite in joint cracks; pyrite in vertical streaks; mother coal and pyrite in horizontal streaks.

Character of the coal: The coal is described by the observer who measured section No. 1 as tough, hard to break, and uniform in quality throughout with no definite line of impurity. Occasional sulphur balls and the clay slips characteristic of No. 5 are present, but not common.

Character of the roof: Above the coal is 2 inches of "draw slate" followed by 1 to 2 feet of dark "slate," in places containing a limestone band or cap-rock up to 18 inches in thickness. Sandstone overlies the black shale and where the shale is thin it always falls. Niggerheads are common in the roof shale.

CRESCENT COAL COMPANY'S NO. 1 MINE ABOUT 3 MILES NORTH OF BARTONVILLE

Entrance: Shaft; 195 feet to the top of No. 5 coal.
Thickness of coal: Average thickness 4 feet 2 inches.[1]
Sections of the coal:

Sections of No. 5 coal in the mine of the Crescent Coal Company

Section 1—Face of the 5th southeast entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, fairly clean	..	10
Mother coal and dirt	..	¼
Coal, dirty	3	6
Floor: Dark gray shale	..	..
	4	4¼

Impurities: Coal contains pyrite, mother coal and dirt in horizontal streaks with calcite in the joint cracks.

Section 2—Face off room 22, off 6th north entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, fairly clean	1	10½
Pyrite parting	..	⅛
Coal, fairly clean	1	2
Mother coal, soft	..	⅜
Coal, dirty	1	..
Floor: Dark gray shale	..	..
	4	1

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[1] Thirty-sixth Annual Coal Report of Illinois: Department of Mines and Minerals, 1917, p. 84.

Section 3—Face of 10th south, off west entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean	..	10½
Mother coal	..	⅛
Coal, dirty, dull	1	2
Mother coal	..	⅜
Coal, dirty, dull	1	2
Mother coal	..	⅜
Coal, fairly clean	2	1
Floor: Dark gray shale	..	..
	4	2

Impurities: Pyrite, mother coal and dirt in horizontal streaks; pyrite in vertical streaks.

COLLIER CO-OPERATIVE COAL COMPANY'S NO. 1 MINE, AT BARTONVILLE

Entrance: Slope; 110 feet to floor of mine.

Thickness of coal: Varies from 4 to 4½ feet; averages 4 feet 3 inches.

Sections of the coal:

Sections of No. 5 coal in mine of Collier Co-operative Coal Company

Section 1—Room 45 off 10th entry off main north;
3,300 feet southeast of shaft

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	18
Coal, clean	4	1
Floor: Fire clay	1	8
	7	3

Section 2[1]—At face of 6th north entry off main west entry

	Thickness	
	Ft.	*in.*
Roof: Dark shale	..	..
Coal, conchoidal fracture	..	5
Coal, rough fracture	3	7
Coal and "sulphur"	..	1*
Floor: Brittle clay	..	..
	4	1

Section 3[1]—At face of room 1, 4th north entry in by 3d north parting

	Thickness	
	Ft.	*in.*
Roof: Dark shale	..	..
Coal, conchoidal fracture	..	7
Coal, rough fracture	1	1
Coal and "sulphur"	..	¼*
Coal	2	6¾
Floor: Brittle clay	..	..
	4	3

*Not included in sample.

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[1] See footnote 1, page 195 opposite.

Section 4[1]*—At face of 5th north entry off main west entry*

	Thickness	
	Ft.	*in.*
Roof: Dark shale	..	..
Coal, conchoidal fracture	..	6
Coal, rough fracture	3	7
Coal and "sulphur"	..	½
Floor: Brittle clay	..	..
	4	1½

Character of the coal: The bed is reported to be fairly uniform with few horsebacks and no rolls or faults.

Character of the roof and floor: The roof is dark shale about 10 feet thick, above which is a limestone cap-rock, having an irregular surface. The floor is a brittle underclay.

The analyses are of samples collected where the sections Nos. 2, 3, and 4 were measured by the U. S. Bureau of Mines.[2]

M. E. CASE COAL COMPANY'S NO. 1 (WALBEN) MINE, SOUTH OF PEORIA

Entrance: Drift; about 16 feet to the top of No. 5 coal.

Thickness of coal: Averages 4 feet 7 inches. The coal thickens greatly near the sandstone "fault," but elsewhere its thickness is very uniform.

Sections of the coal:

Sections of No. 5 coal in Walben mine of the M. E. Case Coal Company

Section 1—Room 43, 7th south off 6th west

	Thickness	
	Ft.	*in*
Roof: Sandstone	..	..
Coal	1	8¾
Clay and pyrite	..	½
Coal	..	6½
Clay and pyrite interlaminated	..	¼
Coal	2	..
Floor: Fire clay	..	..
	4	4

Section 2—End of 7th south off 6th west

	Thickness	
	Ft.	*in*
Roof: Black slate	..	..
Coal	1	9
Pyrite and clay intimately laminated	.	½
Coal with some streaks of clayey mother coal	2	½
	8	10

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[1] Fieldner, A. C., Smith, H. I., et al. Analyses of mine and car samples of coal collected in the fiscal years 1913 to 1916: U. S. Bureau of Mines Bull. 123, pp. 178, 179, 1918.

[2] U. S. Bureau of Mines Bull. 123, p. 35.

Character of the coal: The coal is uniform in its general characteristics. The bed commonly carries a layer of intimately interlaminated pyrite and carbonaceous clay known as brown "sulphur" about 2 feet below the top, but this impurity is not persistent. Horsebacks are common and are of some special interest because the breaks generally continue up into the sandstone which lies upon or a short distance above the coal. In the 3d west entry off the 4th south, the sandstone at one place showed an open crevice above a horseback out of which the gage has fallen for a height of 15 to 20 feet. Clay shale shows in the top of the crack. It was not clear whether the clay was a continuation of the filling or a shale bed above the sandstone. The crack looked like a crack that had been produced or at least widened by weathering, the sides being rounded, or smoothed rather than clean and sharp. There was essentially no offset of any of the beds.

Below the horseback the clay floor is commonly raised in a ridge suggesting that probably there was some movement of the floor clay into the crack when it opened. The character of the lower clay is quite different from that filling the larger part of the fissure, this material apparently coming from some strata above the coal. These rolls in the floor clay are taken up by the miner, for which extra pay is given.

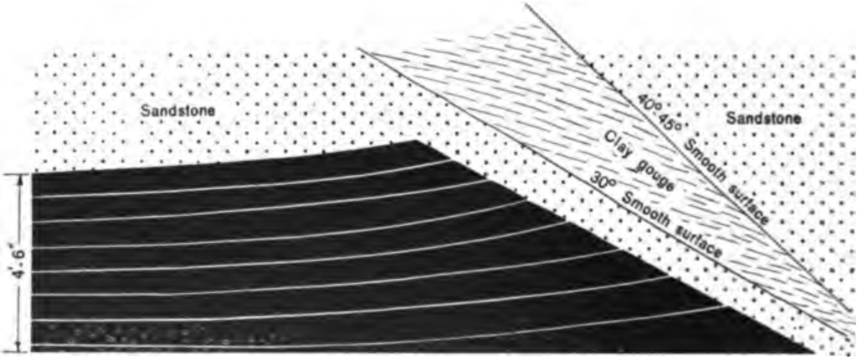

FIG. 25.--Sketch of the contact of coal and "fault" in the 6th west off main north entry of the M. E. Case Coal Company's No. 1 (Walben) mine

The operation of this mine is limited on the west by a sandstone "fault" which cuts out the coal (fig. 22). The sandstone apparently occupies a channel which penetrates the coal bed. The rock is a gray micaceous sandstone of about the same character as that forming the roof of much of the mine. At some places the coal feathers out under the sandstone and at others it terminates very abruptly against the sandstone. The nature of the contact at one place along the "fault" is shown by the accompanying sketch (fig. 25).

Character of the roof: The immediate roof varies from the usual succession of black "slate," clod and cap-rock to merely sandstone. The sandstone apparently lies irregularly upon the underlying strata, in places resting directly upon the coal and in other places separated from the coal by a greater or less thickness of the typical roof.

Character of the floor: The underclay, about 18 inches thick, is underlain by an "iron band" 10 inches thick. The clay heaves somewhat in wet places, and the clay tends to "roll" up in the floor beneath the horseback fissures, rising nearly 12 inches in some cases.

LEITNER COAL COMPANY'S NO. 1 MINE, NORTHEAST OF ORCHARD MINES

Entrance: Drift mine; No. 5 coal.

Thickness of coal: Varies from about 4 feet to 6 feet; averages 4½ feet. The coal thickens markedly near its contact with the sandstone "fault" (fig. 15); elsewhere it is practically uniform in thickness.

Sections of the coal:

Sections of No. 5 coal in the Leitner Coal Company's mine
Section 1—6th south entry

	Thickness *Ft.*	 *in.*
Roof: Black slate	..	..
Coal, laminated, and with thin streaks of mother coal	1	7½
Pyrite; mixture of clay, organic matter and pyrite. Called "brown sulphur" by miners	..	3
Coal, like top coal	2	10½
Pyrite or clay, hard	..	½
Coal	..	½
Floor: Fire clay	..	..
	4	10

Section 2—5th south entry.

	Thickness *Ft.*	 *in.*
Roof: Black slate with coal stringers	..	..
Coal	..	11½
Pyrite and clay	..	2
Coal	1	½
Pyrite and clay	..	2
Coal	2	11
Pyrite streak in bottom	..	..
Floor: Fire clay	..	..
	5	3

Section 3—Face main west entry

	Thickness *Ft.*	 *in.*
Coal	1	4
Pyrite and clay	..	2½
Coal	2	6
	4	½

Section 4—Room 12, back west entry

	Thickness	
	Ft.	*in.*
Roof: "Slate"	..	..
Coal	1	1
Pyrite band	..	1½
Coal	..	11½
Pyrite and clay	..	2
Coal	2	..
Floor: Fire clay	..	..
	4	4

Character of the coal: The bed contains a fairly continuous band of "brown sulphur" about 18 inches to 2 feet from the top. Not uncommonly two such bands are present.

The horsebacks in this mine are very numerous. The mine map shows that the "fault" is encountered on the west side, trending about northeast-southwest from the S. W. cor. sec. 2, Hollis Township (T. 7 N., R. 7 E.). The same or another body of sandstone is also present at the usual horizon of the coal in section 11.

Character of the roof: The ordinary roof consisting of black shale, clod, and cap-rock is present except where the sandstone has cut down to the coal. The parting between the coal and the shale roof is poor and commonly the lower 4 to 6 inches of the roof comes down with the coal. It is rather difficult to separate the shale from the coal, so that the waste material thrown into the gob contains considerable coal.

MAPLETON COAL COMPANY'S NO. 1 MINE, AT MAPLETON

Entrance: Slope; No. 5 coal.

Thickness of coal: Uniform; varies between about 4 feet 4 inches and about 4 feet 10 inches; averages 4 feet 6 inches.

Section of the coal:

Section of No. 5 coal in the mine of the Mapleton Coal Company
Measured in a room off the main west back entry

	Thickness	
	Ft.	*in.*
Coal with streak of pyrite in upper inch	2	6
Coal, dirty	..	1/16
Coal	1	2 11/16
Mother coal	..	¼
Coal	1	..
	4	9

Character of the coal: The coal is very uniform and clean. About the only impurities are a few "horsebacks" and a few discontinuous clay and mother-coal bands 1/16 of an inch thick or less. Because of the great regularity of the coal, no special description of the seam is necessary.

Character of the roof: The roof is constant in character. The succession consists of the usual black "slate," clod, and cap-rock. The first is 12 to 14 inches thick, the second 14 to 16 inches, and the last 2 to 6 inches, lying from 24 to 30 inches above the coal. Above the cap-rock is gray shale. Although in places the cap-rock is rather soft and shaly, generally it forms a solid roof. The black shale or "slate" roof carries a few niggerheads lying in the "slate" and coal.

Character of the floor: The floor is fire clay; it heaves some where damp and rolls up under horsebacks.

EAST MAPLETON COAL COMPANY'S "EAST" MINE, AT MAPLETON

Entrance: Drift; No. 5 coal.

Thickness of coal: Varies from 4 feet 6 inches to 5 feet 8 inches; averages 5 feet.

Character of coal: The coal is very irregular due to horsebacks and persistent pyrite bands. The coal runs nearly 12 inches thicker than in other mines and the irregularities in thickness are greater. The horsebacks, commonly 2 to 3 feet through, are present almost constantly in the face. The cracks running up into the roof cut it up like a mosaic. The floor below is offset along lines matching the cracks in the roof, giving a relief of 8 to 12 inches.

The sulphur bands consist largely of the "brown" laminated pyrite. An almost continuous streak, generally 1½-inch thick and in places 6 to 9 inches lies about 24 inches from the top. These impurities and irregularities make mining very expensive, as it is probable that about half the material taken out of the mine is rock waste.

The sandstone "fault" of the region is reported to lie a short distance north of the present workings of the mine.

NEWSAM BROTHERS' NO. 4 MINE, AT GLASFORD

Entrance: Shaft; 148 feet to the top of No. 5 coal.

Thickness of coal: Practically uniform; varies from 4 feet 4 inches to 4 feet 6 inches.

Character of the coal: The coal lies in a single bench with few irregularities. Horsebacks though present are not especially numerous. Some pyrite is encountered in streaks, balls, and lenses. Pyrite lenses averaging about 1 inch thick by 6 to 7 inches across are especially common near the horsebacks. They begin to appear 6 to 8 feet back from the fissure. Some of the horsebacks have a large per cent of pyrite in them and are very hard to mine.

Character of the roof: The roof consists of 6 to 14 inches of black "slate," 6 to 8 inches of clod, and 8 to 10 inches of limestone cap-rock. The parting between the coal and black shale is poor, due to the presence of pyrite balls and lenses at this position. The pyrite tends to bind the coal to the "slate" so that either the upper few inches of coal is left in the roof or else the lower part of the shale comes down with the coal. In the latter case the shale with 3 or 4 inches of attached coal is usually thrown into the gob.

Character of the floor: Fire clay, which is reported to heave when wet, forms the floor.

NO. 2 COAL

The coal which has been reopened during the last year in the mine at Pottstown, and the coal formerly mined by the Third Vein Coal

Company at Orchard Mines, and which is encountered in several drill holes in the county 117 to 140 feet below No. 5 coal, is believed to be the No. 2 bed.

The thickness of the coal averages about 2½ feet, or about two-thirds the thickness of No. 5 in this region and about 1 foot thinner than No. 2 coal in the La Salle and Spring Valley region. Here as elsewhere the coal is apparently regular in thickness, and uniform in character over large areas. Impurities that could seriously affect the value of the coal are lacking. The brassy nodules of pyrite typical of this coal are present, but because their contact with the coal is sharp and clean, they can be readily removed at the face. The pyrite impregnates the surrounding coal little if any, in contrast with the many pyrites lenses in other coals, and it is therefore generally unnecessary to discard much coal with the sulphur balls.

Roof conditions are normal for No. 2 coal. The "soapstone" or gray shale and black "slate" found in succession above the coal in the Longwall District[1] seems to be very widespread. The succession in this field seems to be the same as that in the northern district. The gray shale or "soapstone" is 9 to 12 feet thick on the average, which is a few feet thinner than at La Salle, and the black "slate" is about 2 feet thick. The "slate" carries large niggerheads or limestone concretions as in other regions. Above the black shale is a limestone about 2 feet in thickness. In places the black shale comes down on the coal cutting out the soapstone.

This coal is always mined by the longwall system, and except for the fact that the coal is thin, conditions are favorable for mining. There is little question but that eventually this bed will be extensively mined in this region, though probably not until the best areas of No. 5 coal are exhausted.

The chemical character of No. 2 coal is discussed briefly in Part I and an analysis of the bed is included in Table 3.

MINE NOTES, NO. 2 COAL

The following notes are based upon observations in two mines operating in No. 2 coal. Of these the Third Vein Coal Company has not been in operation for several years, the observations having been made in 1908.

THIRD VEIN COAL COMPANY'S ABANDONED MINE IN NW. ¼ SEC. 14, T. 7 N., R. 7 E.

Entrance: Shaft; 162 feet to the top of No. 2 coal.

Thickness of coal: Varies from 2½ to 3½ feet; averages about 2 feet 11 inches.

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[1] Illinois Coal Mining Investigations Bull. 10, 1915.

Section of the coal: The coal was measured southwest of the shaft in room No. 5 off the first straight south(?) entry. The coal was 32 inches thick, with gray shale roof and fire-clay floor.

Character of the coal: The coal contained one sulphur lens which in the face measured 1 by 6 inches. Such lenses were reported to be rare and to occur at any place in the bed. The coal is described as "long grain."

Character of the roof: The shale or "soapstone" is a slabby dark-gray shale with small lenses of light-gray, sandy shale 1 inch thick. The gray shale is generally 8 to 12 feet thick, but is absent in places, the black "slate" resting on the coal. The "soapstone" is slabby, dark gray, and contains small 1-inch thick lenses of light-gray sandy shale. The black "slate" above is thin, shelly, hard, and brittle, with half-inch lumps on the bedding planes, and is reported to be about 10 feet thick. It contains niggerheads commonly as large as 12 by 6 by 24 inches.

Character of the floor: The floor is fire clay which is at least 6 feet thick. At one place it has been drilled into to a depth of 12 feet.

JOHN A. HOFFMAN'S "BLUE FLY" (WANTLING) MINE, AT POTTSTOWN

Entrance: Shaft; 107 feet to the top of No. 2 coal.

Thickness of coal: Varies from 2 feet 4 inches to 2 feet 8 inches; averages 2½ feet.

Sections of the coal:

SECTIONS OF NO. 2 COAL IN THE "BLUE FLY" MINE, AT POTTSTOWN

Section 1

	Thickness	
	Ft.	*in.*
Roof: Gray shale or "soapstone" containing small lime and pyrite concretions, 9 feet or more	..	..
Coal, clean	1	9 7/16
Pyrite streak	..	1/16
Coal	..	3
Clay band	..	½
Coal	..	4
Floor: Fire clay	..	..
	2	5

Section 2—50 feet south of shaft

	Thickness	
	Ft.	*in.*
Roof: Gray shale	..	..
Coal, containing one sulphur ball 4 inches thick	2	6
Floor: Fire clay	..	..
	2	6

Section 3—End of southwest entry

	Thickness	
	Ft.	*in.*
Roof: Gray shale	..	..
Coal	2	6
Floor: Fire clay	..	..
	2	6

Character of the coal: The seam is practically uniform throughout the mine. The few partings are not persistent, but sulphur lenses and balls occur at various positions. Many seem to be pyritized parts of plants. These average in size about ¼ by 8 to 10 inches; some are as large as 4 by 12 to 14 inches. The amount of pyrite present is estimated to be between 1 and 2 per cent by weight of the coal.

The coal is rather hard and bright. Some cleat is developed, the fracture being north and south, and at right angles. Vertical sheets of pyrite are present but are not persistent in some of the joint cracks.

Character of the roof: The roof rock is typical "soapstone" about 9 feet thick. Above this is 2 feet of black "slate" which is capped in turn by a 2-foot limestone.

Character of the floor: The floor clay is a gray, even-textured clay which is reported to be 3 to 4 feet thick. Its character is not well known. It probably will heave if wet.

NO. 1 COAL

No. 1 coal has been worked in the mine at Pottstown at a depth of 240 feet, 133 feet below No. 2 coal. Udden[1] states that the lower bed consists of a lower bench varying in thicknes from 2 feet 2 inches to 3 feet, a parting of shale less than 3 feet thick, and an upper bench, 1 foot 2 inches to 1 foot 4 inches thick. Where the parting between the two benches was not too heavy, both were mined. The coal is of fairly good quality, but the mining was too expensive for the market at the time, and operations ceased more than ten years ago.

In general it is believed that this seam of coal is probably too thin to be of commercial importance for many years. It is possible, however, that there is beneath it a clay of commercial value, which if mined with the coal could be profitably extracted. Unfortunately, information in regard to the quality of the clay is not definite. Clays of commercial importance, however, are known to underlie the horizon of No. 1 coal in other parts of the State, especially in the counties west and south of Peoria County, so that exploration might be rewarded by discovery of similar clays in this county.

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[1] U. S. Geological Survey Bull. 506, p. 80.

SANGAMON COUNTY

PRODUCTION AND MINES

Production in tons from No. 5 and No. 6 coals, year ending June 30, 1920	6,844,049
Production in tons from No. 5 coal, year ending June 30, 1920	4,485,434
Average production from No. 5 and No. 6 coals, 1916-1920, inclusive	6,696,458
Average production from No. 5 coal, 1916-1920, inclusive	4,564,363
Total production, from No. 5 and No. 6 coals, 1881-1920	129,054,297
Total production from No. 5 coal, 1881-1920	85,000,000±

The total production of coal from Sangamon County for the year ending June 30, 1920, was a little more than 9 per cent of the State's entire output. The production of No. 5 coal in the county was about two-thirds of the combined production from No. 5 and No. 6 coal. Six shipping mines in the southern part of the county report a production of 2,358,615 tons of No. 6 coal; and 22 shipping and 4 wagon mines in the northern part of the county produced 4,485,434 tons of No. 5 coal. Sangamon County as a whole ranked fourth among the counties of the State. The shipping mines in operation in 1920 are listed in Table 6.

COAL BEARING ROCKS

Information concerning the geological succession of the northern part of Sangamon, where No. 5 is the important coal mined, is contained in a report on the Springfield quadrangle by T. E. Savage[1], and in an earlier report on the geology and mineral resources of the Tallula and Springfield quadrangles by E. W. Shaw and T. E. Savage.[2]

These two publications will be largely drawn upon in describing the coal-bearing rocks and the character of the coals.

The record of a deep hole is included in Part I and used in Plate II.

The following extract from State Geological Survey Bulletin 20 describes particularly the rocks underlying the Springfield quadrangle but applies generally to all that part of the county covered by this report.

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[1] Savage, T. E., The Geology and mineral resources of the Springfield quadrangle: Illinois State Geological Survey Bull. 20 pp. 97-130, 1915.

[2] Shaw, E. W., and Savage, T. E., U. S. Geological Survey Geol. Atlas: Tullula-Springfield folio (No. 188) 1913.

KINDS OF ROCK IN THE AREA

"The rocks of the Springfield quadrangle consist of: (1) surficial materials, composed of unconsolidated beds of glacial till or drift loess, sand, and alluvium which have been derived from the breaking down of pre-existing rocks; and (2) sedimentary rocks, which underlie the surficial materials and consist of more or less consolidated bed of sandstone, shale, limestone, and seams of coal, arranged in nearly horizontal layers.

SURFICIAL MATERIALS

"The surficial materials in this area comprise glacial, aeolian, and fluvial deposits, which cover the sedimentary rocks to an average depth of about 35 feet. They are thinnest over the areas that formed the highlands in the pre-glacial time and are thickest above the valleys of the early Pleistocene streams. Sangamon River follows such an old valley along its northward course near the west side of the quadrangle. Over this valley a well in the NW. ¼ sec. 23, T. 18 N., R. 6 W. was put down 170 feet without reaching the bottom of the surficial materials. The altitude of the bottom of this drilling was 125 feet lower than the surface of the consolidated rocks two miles farther east.

INDURATED ROCKS

GENERAL DESCRIPTION

"The hard rocks of this region have been studied in natural exposures through a thickness of 225 feet. By means of test borings for coal and oil they have been explored to a depth of 1,500 feet. Columnar sections of the logs of representative coal shafts and test borings are given in Plate VII. These show in detail the character and sequence of the strata that underlie the surface materials as far as they have been explored in this region. All the information concerning the rocks underlying the Pennsylvanian strata in this area is obtained from a drilling near Springfield, a log of which is shown in section 1, Plate VII. The succession and geological position of these rocks are also shown in the following generalized section.

Generalized section of hard rocks known in the Springfield quadrangle

	Thickness *Feet*
Pennsylvanian system—	
McLeansboro formation—including all of the Pennsylvanian strata above the top of No. 6 coal, and composed of shales, sandstones, some impure limestones, and thin coals........	**46–225**
Carbondale formation—embracing all of the strata between the base of No. 2 coal and the top of No. 6 coal; and consisting of shales, sandstones, limestone, and productive coal beds; about	**243**
Pottsville formation—comprising the strata between the bottom of the Pennsylvanian and the base of No. 2 coal, and composed mostly of sandstones in the lower and shales in the upper part, with interbedded thin coals; about.........	**278**
Mississippian system—	
Salem and St. Louis formations—predominantly limestones with some shales; about.................................	**215**
Keokuk and Warsaw formations—dominantly shales with some limestones; about	**164**
Burlington formation—cherty limestones and chert; about....	**106**
Kinderhook formation—greenish to bluish-gray shale, limestone and red shaly limestone; about...................	**155**
Devonian system—	
Upper Devonian series—dark shale with spores of *Sporangites* abundant; about	**133**
Middle Devonian series (Hamilton of Iowa or Northwest province)—gray limestone; to bottom of boring..........	**28+**

POTTSVILLE FORMATION

"Pottsville strata comprising the base of the Pennsylvanian system have been explored in three deep borings. They consist of coarse, gray sandstone and some conglomerate in the lower part, and shales or sandy shales predominating in the middle and upper portions. A thin coal bed lies 140 feet from the base and a somewhat thicker coal about 100 feet above the former and 33 feet below the bottom of No. 2 coal.

CARBONDALE FORMATION

"It has seemed desirable by the Survey to use the name Carbondale as a substitute for, and to make it embrace all the strata that were included in, both the Petersburg and the La Salle formations as described in a previous report.[1] This is the important coal-bearing formation in the State. Its basal member, No. 2 coal, consists usually of two thin beds separated by about 4 feet of dark shale. Above this coal is a shale which is followed by sandstone, and that succeeded by dark-colored shale up to an 18-inch coal bed, about 80 feet above coal No. 2. Between this coal and the next higher coal bed is an interval of about 55 feet, occupied almost exclusively by dark shale. Above this coal gray or blue to black shales extend to coal No. 5 which lies about 54 feet above the next lower coal.

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[1] De Wolf, F. W., Introduction to studies of Illinois coal: Illinois State Geological Survey Bulletin 16, p. 180, 1910.

"No. 5 (Springfield) coal is the important coal seam in this region and has an average thickness of about 6 feet. It contains numerous characteristic clay seams or 'horsebacks' which extend down into it, or through it, in a more or less vertical direction. The roof of this coal consists of 3 to 5 feet of black, laminated, fissile shale bearing numerous shells of *Orbiculoidea missouriensis* and other fossils, and containing in the lower part numerous rounded nodules ('nigger-heads') of calcareous pyritic shale. A limestone cap rock, generally about 12 inches thick, overlies the black shale, and is followed by 1 to 4 feet of light-colored shale. No. 6 coal lies about 50 feet above No. 5 coal and, with the exception of No. 5 cap rock, the strata lying between these coals are mostly shale.

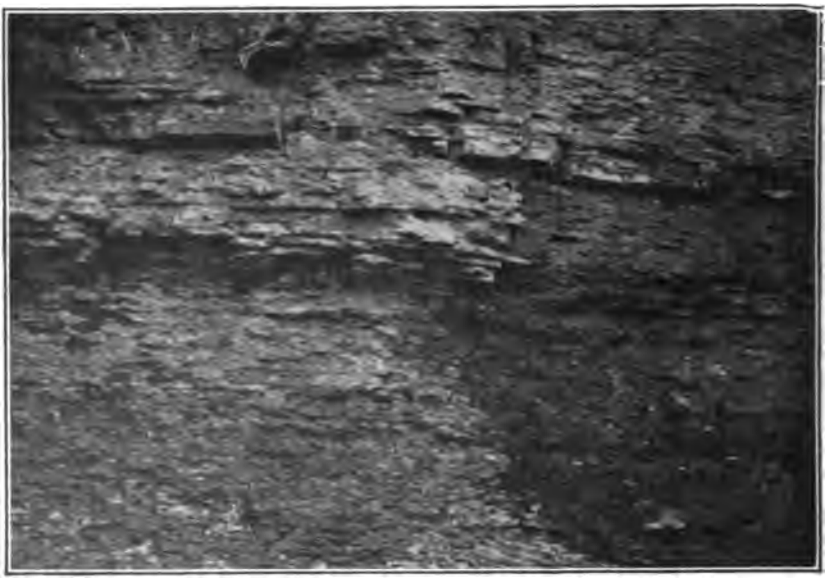

Fig. 26.—Photograph of a shale bed a short distance above No. 7 coal, exposed in the south bank of Spring Creek, NE. ¼ sec. 25, T. 16 N., R. 6 W.

"Within the quadrangle No. 6 coal is only 2 to 14 inches thick, but it becomes thicker and has been mined at Mechanicsburg to the east and at Chatham to the south, only a short distance from the borders of this area.

MCLEANSBORO FORMATION

"The roof shale of No. 6 coal, the basal member of the McLeansboro formation, is 3 to 5 feet thick. It is followed by about 6 feet of limestone which contains *Fusulina ventricosa* as the characteristic fossil. A thin coal (No. 7) 3 to 4 inches thick, occurs about 45 feet above the No. 6 bed. Between these coals are several feet of red, mottled shales which are exposed at Ralls Ford on Sangamon River, and constitute a very characteristic and easily recognized horizon throughout this region. The shale may, for convenience, be called the Ralls Ford shale member. Above No. 7 coal there follows a bed of bluish-gray shale with occasional sandy layers about 45 feet thick, exposed in the south bank of Spring Creek in the NE.¼ sec. 25, T. 16 N., R. 6 W., and shown in figure 26.

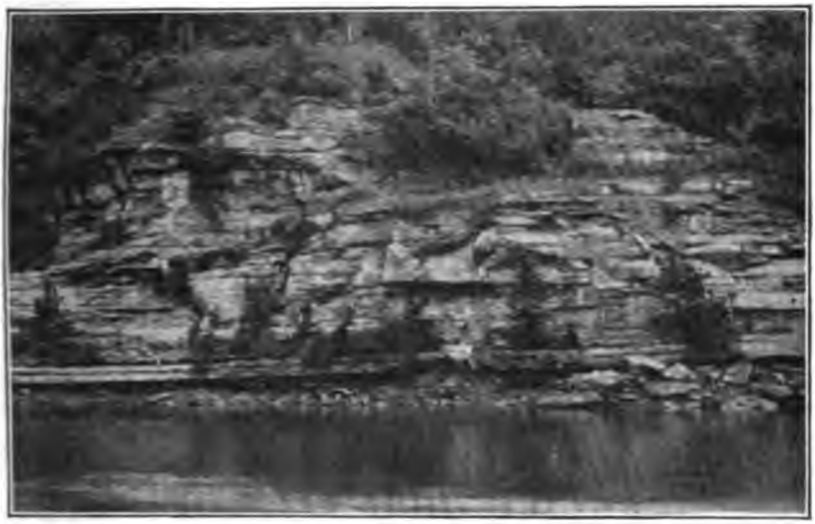

FIG. 27.—View of sandstone below No. 8 coal, exposed in the north bank of Sangamon River at Carpenter's bridge, NW. ¼ sec. 1, T. 16 N., R. 5 W.

"Over a very limited area near the extreme northwest corner of the quadrangle there outcrops along Indian Creek about 6 feet of hard, gray, partly brecciated limestone which is better exposed in the banks of Rock Creek a few miles west of Athens. This limestone is thought to correspond with the Lonsdale quarry limestone in the Peoria quadrangle. Over the greater portion of the Springfield area this limesto is wanting, but its place appears to be at the top of the shale bed ab No. 7 coal.

"Above this shale are 30 or more feet of sandstone exposed in north bank of Sangamon River at Carpenter's bridge, NW. ¼ sec. 1, 16 N., R. 5 W. (see figure 27). A few feet of shale separates sandstone from No. 8 coal and associated beds.

"No. 8 coal, the underclay below, and the roof shale and cap r above, comprise a succession of strata that are easily recognized in logs of mine shafts and test borings in the central and eastern portio of the area. They outcrop in the west bank of Sugar Creek, sec. 13, 15 N., R 5 W.; in the south bank of the Sangamon River, sec. 6, T. N., R. 4 W.; and in the east bank of Fancy Creek, sec. 13, T. N., R. W.

"Above the limestone overlying No. 8 coal is 40 or 50 feet of sha exposed in the shale pit of the Springfield Paving Brick Co. nea Springfield. This is followed by about 35 feet of sandstone whic outcrops along Sangamon River near the middle of sec. 4, T. 15 N R. 4 W., and in the south half of sec. 27, T. 16 N., R. 4 W.

"Belonging a few feet above this sandstone is the Crow's Mill lime-stone, exposed in the old quarry near Crow's Mill along Sugar Creek about 3 miles south of the quadrangle. This is a hard limestone, bear-ing large shells of *Productus, Spirifer,* and *Composita.* It occurs i heavy layers, large masses of which, more or less shifted by the ic sheets of the glacial period, are present in the area under discussion."[1]

Structure

The structure of that part of Sangamon County which is included within the Tallula and Springfield quadrangles has been determined with as great detail as possible and the lay of the rocks as determined by the altitude of No. 5 coal is shown by maps in the U. S. Geological Folio 188.[2]

The structure map of the county, Plate VIII, is relatively detailed for the area included within the Tallula and Springfield quadrangles; but the structure for the part of the county east of the quadrangles is based on very scattered data and estimated elevations, and accordingly is shown by dashed contour lines.

The following statement from the Tallula-Springfield folio summarizes the structure in that area. The description includes the adjacent southeast portion of Menard County.

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[1] Savage, T. E., The geology and mineral resources of the Springfield quadrangle: Illinois State Geological Survey Bull. 20, pp. 102-107, 1915.

[2] Shaw, E. W., and Savage, T. E., Geological Survey Geol. Atlas: Tallula-Springfield Folio (No. 188), 1913.

STRUCTURE OF THE TALLULA AND SPRINGFIELD QUADRANGLES

"As a rule the strata of the Tallula and Springfield quadrangles dip somewhat south of east at the rate of about 10 feet to the mile, but this general dip is modified by low folds and minor irregularities, most of which are too-ill defined to be described separately but which are shown on the maps by contours drawn at intervals of 25 feet on the base of the Springfield coal. These irregularities are the product of irregularities in the surface upon which each layer was deposited and of differential settling and warping since deposition. The prevalent eastward dip is, in part at least, the result of deformation. It carries the base of the Carbondale formation from a position about 200 feet below the surface at the western side of the area to one nearly 600 feet below the surface on the eastern side. This general dip is modified by a syncline just east of Tallula, by an anticline extending southwestward from Springfield, and by many minor irregularities. The syncline east of Tallula is steeper on its west side, as might be expected on account of the prevailing eastward dip. In the mine of the Tallula Coal Co. the dip is so steep that the mine cars on an eastward trip must be 'spragged' or otherwise held in check. However, even where steepest, the dip dos not exceed 60 feet to the mile. In the northeastern part of the area the predominant dip is eastward and is about 10 feet to the mile. In the southern part the general dip is southeastward but is modified by a syncline and anticline which enter the area near the middle of the southern side. The anticline extends northeastward as far as Springfield, whence it curves to the southeast, passing near the village of Keys. West of Springfield the strata in the flanks of the arch dip 15 feet to the mile, but east of Springfield they be progressively flatter on both sides of the axis, for the anticline plunges southeastward in conformity to the general dip.

"In some areas the Springfield coal is almost level throughout several square miles; in others it dips more than 20 feet to the mile. In some places its dip differs from the general slope or is even opposite to it. In most of the mines, however, it has almost no perceptible dip, and throughout a considerable area between Pleasant Plains and Salisbury the coal bed and the other strata seem to lie practically horizontal. In the southeast quarter of the Tallula quadrangle the beds so far as is known dip regularly southeastward at the rate of about 15 feet to the mile, but in that district few borings have reached the coal and some of the structural features may have not yet been brought to light. Indeed, throughout a considerable part of this quadrangle no borings have reached recognizable strata, and the structure map therefore lacks many details which can be shown when the coal has been worked more extensively, but the mine shafts and borings already sunk are rather uniformly distributed, so that the major structural features as shown are believed to be approximately correct."[1]

COALS

COALS BELOW NO. 5

"A fairly persistent coal bed about 2½ feet thick lies about 58 feet below No. 5 coal. Another bed, which seems persistent, occurs about 120 feet below No. 5 coal, and averages about 2 feet in thickness. Two other coal beds which are locally present, aggregating about 3 feet in thickness and separated by a few feet of shale, lie at a depth of about 191 feet below No. 5 coal. In the Riverton section a 32-inch coal was reported 250 feet below the No. 5 bed, but in the Springfield boring the corresponding coal is much thinner. A few other thin bands occur locally in the Pennsylvanian strata below No. 5 coal. At some future time one or more of these lower coals may be of economic importance, but until the No. 5 bed becomes practically exhausted, the deeper and thinner coals will not be exploited.

NO. 5 COAL

CHARACTERISTICS OF NO. 5 COAL

"The coal known as No. 5 (Springfield) is the only bed at present worked in the quadrangle. Its thickness varies but little in the different mines, the range within the area being from 5½ to 6⅜ feet. It lies entirely below drainage, being found at depths from 150 to 273 feet below the surface. The depth to the coal at any one place depends both upon the altitude of the surface and the altitude of the coal at that place. No. 5 coal is remarkably uniform and persistent, being found at every place where borings have been put down to its level, and it is also present in the State over an extensive territory to the west and south of the area.

CLAY SEAMS IN NO. 5 COAL

"One of the conspicuous features of No. 5 (Springfield) coal is the occurrence in it of numerous "horsebacks," as they are called by the miners. These are more or less irregular and branching fissures filled with clay or shale, extending downward from the overlying beds into or through the coal. They range in width from 2 of 3 inches to 3 or 4 feet, the walls not being very nearly parallel, and are considerably and abruptly wider in the coal than in the overlying roof shale. (See fig. 28.)

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[1] Op. cit.

"The clay or shale filling the fissures is light gray and generally soft. Rarely it is hard enough to emit sparks when struck with a hammer, but as a rule it soon slakes down into an incoherent mass on exposure to the air. The clay in many fissures contains fragments of black shale derived from the roof of the coal, reaching down 29 inches below the top of the coal. A few fragments of limestone from the cap rock are also found in this clay below the top of the coal bed. In horsebacks that cut through the coal bed pieces of coal have been found as much as 9 inches below the bottom of the bed. No fragments of coal have been found higher than the top of the coal bed.

"The fissures show no regularity of spacing or of direction. In some mines they are 40 to 60 feet apart; in others they are separated by 200 to 400 feet or more. They trend in various directions, no one direction predominating, even in the same mine. All are either vertical or steeply inclined, with irregular walls which gradually converge downward within the coal. They have a very slight vertical range. In the Mechanisburg mine a coal bed, formerly worked, lies about 35 feet above No. 5 coal, which is the coal now mined. Although No. 5 coal is cut by numerous horsebacks, none were encountered in the higher bed.

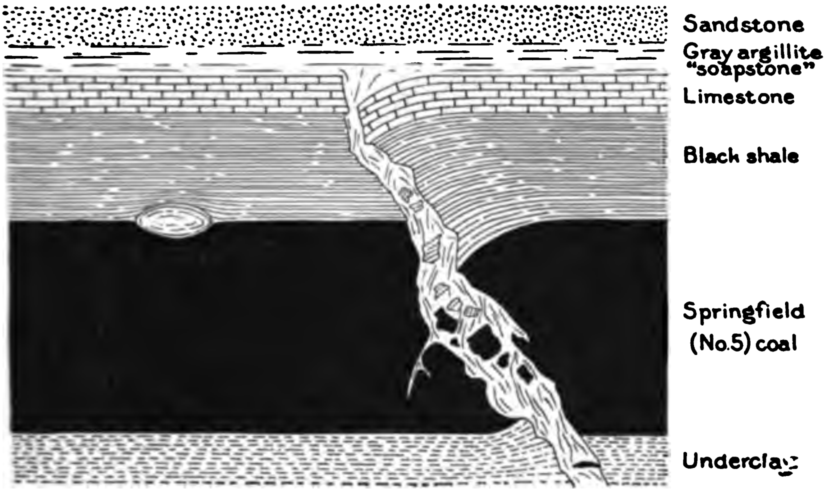

FIG. 28.—Sketch of typical clay seam or "horseback" seen in the Springfield Coal Mining Company's No. 5 mine, near Springfield.

"The walls of the fissures are slickensided but show no traces of weathering. Slickensided planes are also common in the clay filling the fissures. If the fissure is inclined, the uppermost laminae of the coal adjacent to the fissure on the overhanging side are bent somewhat steeply downward, the distortion fading out laterally within a few feet from the fissure, and in a few places the lowermost laminae of the coal on the other side of the fissure are bent upward, but to a much less degree. If the fissure is vertical, or nearly vertical, the uppermost laminae of the coal are bent downward on both sides of the fissure, but the more nearly vertical the fissure the less the amount of bending. In no fissure is there a true fault or a relative displacement of the middle part of the coal bed on the opposite sides of the fissure.

"The material filling the fissures appears to have been derived chiefly from the gray shale overlying the cap rock of the coal bed and to have been forced downward into the coal through breaks in the cap rock, as is indicated by the downward bending of the edges of the cap rock and of the coal laminae, by the occurrence of the fragments of the cap rock below the top of the coal, and by the continuity of the material of the fissures with that of the bed of gray shale.

"The coal appears to have yielded readily in a lateral direction, as shown by the greater width of the fissures in the coal bed than in the overlying and underlying strata. That the coal afforded accommodation to the strains causing the fissures is also indicated by the fact that many of the smaller fissures divide within the coal bed into branches which eventually die out in the coal.

"[illegible] of Clay Seams.—The formation of the clay-filled fissures in the Springfield coal was probably determined in part by the character of the overlying strata and in part, possibly, by the character of the underclay which is dry and does not creep readily. The fissures were formed after the coal bed had been compressed nearly to its present thickness, as is shown by the fact that the clay seams are not so [illegible] as they would be if the coal had been greatly compressed [illegible] from the fissures has [illegible] had been [illegible] of the clay seams. Camp- [illegible] the lignitic [illegible] planes along [illegible] con- [illegible] were formed [illegible]

[illegible] coal [illegible] to [illegible] after [illegible] pos- [illegible] different [illegible] parts of the bed was equalized by the movement of some of the mass toward points of least resistance. When the consolidation reached a certain stage such adjustment was no longer possible, so that continued unequal shrinkage of the mass produced unequal strains in the roof of the coal under its load of superposed rocks. Where the roof of the coal bed was a somewhat plastic shale the mobility of the particles of the shale permitted an adjustment of the inequalities of strain, resulting from the unequal contraction of the coal bed, the adjustment being accomplished by the formation of rock rolls such as are common at the top of the No. 6 (Herrin) coal in the Carterville-Zeigler region of southern Illinois. The roof shale in the vicinity of the rolls is cut by slickensided zones for several feet from the center of the roll, indicating a considerable lateral movement in the shale during the adjustment necessitated by the strains. The roof of the Springfield coal, however, is a hard, brittle shale without the mobility requisite for such adjustment. If the limestone cap rock had been very thick it might have withstood, without fracture, the strain due to unequal contraction in the underlying coal, but its average thickness is only 12 or 14 inches. The roof shale and the cap rock were together not strong enough to withstand the unequal strains to which they were subjected and broke under the pressure, at places marked by fissures.

"Immediately above the cap rock is a bed of rather soft gray shale, the material of which was squeezed downward through the fissures into the coal until the inequalities of pressure were adjusted. The adjustment was limited to a narrow zone below the fractures in the roof shale and cap rock, and its effects are of slight horizontal extent but penetrate to considerable depths.

CONCRETIONS ABOVE NO. 5 COAL

"Rounded concretions of calcareous, pyritic shale, called pyrite balls or 'niggerheads' and varying in size from one inch to four feet or more in diameter, are in places numerous along the contact zone of the black shale with the top of the coal. These concretions have been compressed less than either the overlying black shale or the underlying coal, and hence the laminæ of the black shale arch upward over the 'niggerheads,' and those of the upper part of the coal bend downward beneath them. The continued contraction of the coal seam, after the partial consolidation of the coal and of the overlying black shale, permitted a sufficient amount of movement to take place around and above the 'niggerheads' to give their surface a slickensided appearance, and to cause them to fall readily from their matrix after the underlying coal has been removed.

NO. 6 COAL

"No. 6 (Belleville or Herrin) coal is known only from the records of mine shafts and test borings, and as far as known is too thin to be profitably worked within this area. This bed was formerly mined at Mechanicsburg some distance east of Springfield and it is mined extensively 20 miles south. The coal where first penetrated by the Mechanicsburg shaft was about 6 feet in thickness, but it thinned rapidly northward, and was abandoned when No. 5 coal was discovered below it. In two of the shaft sections it was reported absent, but in these the horizon was marked by a black shale underlain by fire clay. This coal lies at an average distance of 49 feet above No. 5 coal, the distance increasing in general toward the north.

"In this quadrangle No. 6 coal varies in thickness between 2 and 14 inches, the average being 4½ inches. The thickness increases rapidly in a southerly direction. Near Waverly it is 3½ feet thick. At Chatham the thickness is between 5 and 6 feet, and at Divernon it is nearly 8 feet thick. This coal is mined extensively in the southern portion of Sangamon County, and farther south in the vicinity of Belleville, Duquoin, Carterville, and Herrin.

NO. 7 COAL

"No. 7 coal is not thick enough to be of economic importance, measuring generally only 2 or 3 inches. In three of the shaft records the horizon is known only by the associated fire clay and black shale strata, the coal itself not being present. The position of this coal is 50 feet above No. 6 coal, and about 100 feet above No. 5 coal.

NO. 8 COAL

"The thickness of No. 8 coal varies from 18 to 31 inches. The bed lies above drainage over the whole of the area except in a belt around 3 miles wide along the east border, and it has been eroded away from a strip of about equal width along the west side of the quadrangle. For several years before the deeper and thicker bed, No. 5, was discovered, this was the only coal worked in the Springfield region. The mining was done by drifts run into the hillsides at points where the bed outcropped above the level of the streams. Traces of such workings may be seen along a branch in W. ½ sec. 32, T. 16 N., R. 5 W.; along the west bank of Sugar Creek in sec. 12, T. 15 N., R. 5 W.; and they are numerous along the south bank of Sangamon River in sec. 5 and 6 T. 16 N., R. 4 W. The greatest measured thickness of this coal was at the Sangamon River localities where it reached

TABLE 7.—*Thickness of the several coal beds in the Springfield and Tallula quadrangles and the distance between them in mine shafts and borings*[a]

Name of mine	Thickness of coal No. 5	Distance between coals No. 5 and No. 6	Thickness of coal No. 6	Distance between coals No. 6 and No. 7	Thickness of coal No. 7	Distance between coals No. 7 and No. 8	Thickness of coal No. 8	Total distance from top of coal No. 5 to base of coal No. 8
	Inches	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*
Riverton Mine No. 1	72	43½	5	39	2	93	24	175
Barclay Coal Mining Co.	73	63	2	48½	?	89½	8	201
Williamsville Coal Co.	68	60	6	52	0	65½	18	179½
Test hole Springfield Colliery Co.	68	43½	0	62	0	54	?	160½
Springfield Colliery Co.	70	43	14	45½	3	76¾	24	169
Escape shaft Capitol Coal Co.	72	48½	0	56	0	58	24	164½
Spring Creek Coal Co.	72	41½	4	48½	2	79+	?	172
Boring ½ mi. SW. of Springfield	76	39	6	43	2	97	18	179½
Total averages	71	48	6	50	2	77	19½	175

[a] Reprinted from Ill. State Geol. Survey Bull. 20, p. 121.

31 inches. No. 8 coal lies at an average distance of about 77 feet above No. 7 coal, and about 175 feet above No. 5 coal.

"No swamp conditions or soil beds seem to have been developed in the interval between No. 5 and No. 6 coals. Between coal beds No. 6 and No. 7 there is generally reported one, and in some instances two, layers of black shale with underclays. In a few places there is a thin bed of coal at one of these levels. Between No. 7 and No. 8 coals there is less frequently reported a clay-shale succession with a rare occurrence of a thin coal bed.

"A comparison of the thicknesses of the coal beds from No. 5 to No. 8, inclusive, and of the distances separating them in various mine shafts and borings is given in Table 7." [1]

Mine Notes

DAWSON COAL MINING COMPANY'S MINE, AT DAWSON

Entrance: Shaft, about 250 feet to No. 5 coal.

Thickness of coal: Average thickness, 5 feet 2 inches.

Character of the coal: The upper foot and the lower foot of the seam are free from pyrite but there are small discontinuous lenses in the middle part. "Horsebacks" and niggerheads are fairly numerous. Some of the "horsebacks" contain much pyrite and are very hard. The coal has a general dip to the east which is interrupted by small rolls or arches, the dimensions of which were not reported.

Character of the roof: The roof is black "slate," 1 to 4 feet thick, and commonly underlies a cap-rock which attains a known thickness of 4 feet and which in turn underlies soapstone 1 to 20 feet thick.

Character of the floor: The underclay is 1½ to 5 feet thick. It is reported to heave.

BARCLAY COAL COMPANY'S ABANDONED MINE, AT BARCLAY

Entrance: Shaft; depth to No. 5 coal about 247 feet.

Thickness of coal: Averages about 5 feet 10 inches.

Character of the roof: The immediate roof is black slate about 3 feet thick, underlying a sandstone cap-rock 2 feet in thickness. The roof is reported to be good.

SANGAMON COAL COMPANY'S NO. 3 MINE, AT CANTRALL

Entrance: Shaft, 206 feet to the top of No. 5 coal.

Thickness of coal: Averages 5½ feet in thickness, with a maximum of over 6 feet.

Character of the coal: The coal is uniform in character and contains thin streaks of pyrite and some pyrite nodules as the principal impurities. These occur in no great abundance. The coal is mostly bright and finely laminated. Clay veins or "horsebacks" are the only important interruption in the continuity of the bed.

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[1] Savage, T. E., Geology and mineral resources of the Springfield quadrangle: Ill. State Geological Survey Bull. 20, pp. 115-120, 1913.

Character of the roof: The immediate roof is commonly black "slate." Locally the "slate" is absent and the cap-rock rests upon the coal. The usual thickness of the limestone cap-rock is about 1 foot, and the "slate" varies up to about 4 feet. Commonly a streak of pyrite occurs in the shale just above the coal, which "freezes" the coal to the shale so that in mining about 1 inch of the coal stays up. This is said to be desirable, as it protects the shale from the air. The slate also contains "niggerheads" which make the roof rather irregular.

Character of the floor: The underclay is about 3 feet thick. It heaves somewhat when wet.

CITIZENS COAL MINING COMPANY'S MINE "A," ½ MILE WEST OF SPRINGFIELD

Entrance: Shaft, 207 feet to No. 5 coal.

Thickness of coal: Where measured the coal had a thickness of 5 feet 4 inches.

Character of the roof: The immediate roof in the mine is black "slate," 1½ to 5 feet thick, but averaging 3½ feet. The cap-rock is a nodular limestone 12 to 14 inches thick; it is followed above by bluish-gray shale about 15 feet thick. Between the coal and black "slate" is commonly a band of pyrite with many fossils. "Niggerheads" are present in the black shale and "horsebacks" cut through the coal.

PEERLESS COAL COMPANY'S MINE, AT SPRINGFIELD

Entrance: Shaft; 223 feet to top of No. 5 coal.

Thickness of coal: Varies from 5 feet to 6 feet 2 inches.

Sections of the coal:

Sections of No. 5 coal in Peerless mine, Peerless Coal Company

Section 1—Room 18, 1st A east entry

	Thickness *Ft.*	*in.*
Roof: Black shale	..	..
Coal, fairly clean	2	7
Pyrite parting	..	..
Coal, fairly clean	3	4
Floor: Fire clay	..	..
	5	11

Section 2—Room 1 off 4B south off east entry

	Thickness *Ft.*	*in.*
Roof: Black shale	..	..
Pyrite	..	1
Coal, fairly clean, dull	2	3
Pyrite parting	..	..
Coal, dirty, streaked with pyrite	3	5
Floor: Dark underclay	..	..
	5	9

Section 3—Room 11, 1st C west entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, fairly clean	5	10
Floor: Underclay	..	..
	5	10

Character of the coal: The coal is rather hard, bright, hackly, banded, and contains a small amount of pyrite in plates along joint cracks and in lenses parallel to the bedding. Although the bed is uniform in appearance throughout, it is somewhat harder at the bottom and the bottom coal is slightly "bony" in places. The clay veins or "horsebacks," which are rather common, vary in width up to more than 3 feet.

Character of the roof: The immediate roof is black shale about 3 feet thick, and the cap-rock is limestone 2 inches to 2 feet thick, averaging 1½ feet. The black sheety shale of the roof contains "niggerheads'' of all sizes up to several feet in diameter, which in most cases project from the roof down into the coal, and around which the coal is always bent. Between the coal and the black shale there is generally an inch or so of black shale and coal, representing a gradation from the coal to the "slate" above. Locally, however, the parting between the coal and the "slate" is sharp.

Character of the floor: The underclay is a dark-gray clay, 6 feet thick at the sump, which heaves when wet.

MECHANICSBURG COAL COMPANY'S MINE (NOT OPERATING), AT MECHANICSBURG

Entrance: Shaft; 300 feet to the top of No. 5 coal.

Thickness of the coal: Average thickness 5 feet.

Character of the coal: The coal is uniform in character from top to bottom with no persistent partings or bands. There is some gypsum along the vertical joint cracks. The coal is finely laminated with more mother coal than is commonly found in the mines near Springfield.

Character of the roof: The roof shale or "slate" is 1½ to 1 foot 10 inches thick, and the cap-rock above, where it is present, is limestone varying up to 1 foot in thickness.

Notes on No. 6 coal: About 27 feet above the bed being operated at the time the above observations were made (1912) is the bed thought to be No. 6 coal which was worked two years before. This upper bed has a 4- to 5-inch blue band near the middle. It is about 5 feet thick and at the shaft lies at a depth of 277 feet. To the west it is higher and is only 2½ feet thick. East of the shaft it becomes 6 feet thick at a distance of 140 feet, dipping 11 feet in the first 55 feet, after which it becomes level. At the air shaft, which is 346 feet north of the main shaft, the coal is 81 feet above its altitude at the hoisting shaft and is only 1 inch thick.

PEABODY COAL COMPANY'S MINE NO 6, AT SHERMAN

Entrance: Shaft; depth to No. 5 coal 198 feet.

Thickness of the coal: Average, 6 feet.

Character of the coal: The coal is laminated, free of dirt band, but contains considerable mineral charcoal. It shows a few pyrite bands as much as 1 inch thick, but these are not persistent. Thin plates of calcite or gypsum occupy the joint cracks. "Horsebacks" or clay slips are numerous. These are generally 2 to 4 inches across and extend various distances into the coal from the top, some cutting entirely across the seam. The filling of some of the horsebacks shows slickensided or smoothed surfaces, and cementation of the filling by calcite or possibly by pyrite is not uncommon.

Character of the floor: The underclay is hard and locally at least is "frozen" to the coal. Practically no bottom was taken up at the time the observations were made (1912).

SANGAMON COAL COMPANY'S MINE NO. 2, AT STEARNES (SPRINGFIELD)

Entrance: Shaft; 250 feet to the top of No. 5 coal.

Thickness of the coal: The coal averages almost 6 feet in thickness.

Sections of the coal:

Sections of No. 5 coal in mine No. 2, Sangamon Coal Company[1]

Section 1—Room 30, off south entry 21, one mile southeast of shaft

	Thickness	
	Ft.	*in.*
Roof: Shale	..	..
Coal	2	..
Mother coal	..	1/8
Coal	1	5
Shale	..	1/8
Coal	2	4
Floor: Fire clay	..	..
	5	9¼

Section 2—Entry 16 off stub entry 4. 4,000 feet northeast of shaft

	Thickness	
	Ft.	*in.*
Roof: Shale	..	..
Coal	1	3
Mother coal	..	1/8
Coal	1	5
Shale	..	¼
Coal	3	3
Floor: Underclay	..	..
	5	11⅜

Character of the coal: The coal is of the usual character for this district. Horsebacks are numerous, with a filling of hard white clay which is somewhat limy and carries small bits of coal. The coal is well jointed.

Character of roof: The roof is a limy shale, 1½ to 4½ feet thick, with a cap-rock 6 inches to 2 feet thick. The shale roof holds up well and is not generally taken down. It carries the usual "niggerheads" which form "pots" projecting down into the coal and which are smoothed or slickensided around their surfaces.

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[1] U. S. Bureau of Mines Bull. 22, p. 510.

Character of the floor: The floor is a hard gray underclay.

SANGAMON COUNTY MINING COMPANY'S JEFFERSON MINE, AT SPRINGFIELD

Entrance: Shaft; depth to the top of No. 5 coal about 240 feet.

Thickness of the coal: Varies from 3½ to 6½ feet, averaging 5 feet 9 inches.

Character of the coal: The "horseback" or clay veins are very numerous, so that they seriously interfere with mining operations. Many extend in a northwest-southeast direction; the miners, however, say that there is no predominant direction in which they run. The coal is commonly faulted down on one side of the "slips," the laminae being bent down on the downthrow side for a few feet back from the break. The similarity of the clay which fills the fissure to the soapstone above the cap-rock indicates that it apparently came from the soapstone through this latter bed. Pieces of the black roof shale are also common in the "clay veins," but no coal fragments are found in the clay above the top of the coal seam. The "horsebacks" commonly extend only part way through the coal, unless they are large. The fissure generally widens in the coal from a narrow opening in the cap-rock.

Character of the roof: The immediate roof is black laminated shale or "slate." At the bottom of the "slate'' and extending up into the shale and down into the coal, are many large niggerheads, some of them large enough to extend across an entry. In places a band of ferruginous limestone, 2 to 6 inches thick, which carries numerous fossils, lies between the black shale and coal. This occupies the same position as the "niggerheads" and is composed of similar material.

Character of the floor: The coal is underlain by an underclay.

SPRINGFIELD DISTRICT COAL MINING COMPANY'S CORA OR NO. 51 MINE, AT ANDREW

Entrance: Shaft; 145 feet to No. 5 coal.

Thickness of coal: Average, 6 feet.

Roof and floor: Clay below coal, and 4 feet or more of limestone above.

SPRINGFIELD DISTRICT COAL MINING COMPANY'S MINE NO. 52, AT RIVERTON

Entrance: Shaft, depth to No. 5 coal 232 feet.

Thickness of coal: Varies from 5 feet 9 inches to 6 feet 2 inches; averages 5 feet 11 inches.

Sections of the coal:

Sections of the No. 5 coal in mine No. 52 of the Springfield District Coal Mining Company

Section 1—Room 2, off 2d north stub off 3d east north, 2,100 feet from the shaft

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, bright	2	..
Blackjack	..	1
Coal, bright	1	4
Pyrite streak	..	⅛
Coal, bright	1	..
Floor: Fire clay	..	..
	4	5⅛

Section 2—No. 6 room off 10th west off main south entry, 5,600 feet from the shaft

	Thickness	
	Ft.	*in.*
Roof: Black slate	..	..
Coal, bright	1	7
Pyrite streak	..	¼
Coal, bright	3	11
	5	6¼

Section 3—Back entry at face of main south entry, 5,700 feet from shaft

	Thickness	
	Ft.	*in.*
Coal, bright	1	..
Pyrite streak	..	½
Coal, bright	2	10
Pyrite	..	¼
Coal, bright	2	3
	6	1¾

Character of the coal: The coal has no unusual characteristics. The main cleat is southeast to northwest and the prevailing dip about 2½ per cent to the east.

Character of the roof and floor: The roof consists of black "slate" 2½ to 4 feet thick, cap-rock about 1 foot thick, and gray shale above the cap-rock. The floor is clay about 4 feet thick, resting upon 14 inches of hard rock below which is more shale.

SPRINGFIELD DISTRICT COAL MINING COMPANY'S MINE NO. 53 (WOODSIDE), AT SPRINGFIELD

Entrance: Shaft, about 245 feet to No. 5 coal.

Thickness of the coal: Varies from 4½ to 6¼ feet; averages 5 feet 10 inches.

Sections of the coal:

Sections of the No. 5 coal in mine No. 53 of the Springfield District Coal Mining Company

Section 1—Room 1 off the 9th west entry off the main south entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, clean, bright	..	3⅞
Mother coal	..	⅛
Coal, fairly clean	5	4
	5	8

Section 2—Room 5, off 8th south entry off southeast entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, fairly clean	2	6
Pyrite	..	⅛
Coal, bright, fairly clean	2	9⅞
	5	4

Section 3—Room 5, off 19th north entry off straight east entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, very hard, bright, clean	4	4¾
Bone and little pyrite	..	¼
Coal, hard, dull, clean	1	4
	5	9

Character of the coal: The coal is reported to lie in three benches; top bench about 1 foot thick, middle bench 3½ feet, and bottom bench 1½ feet. The coal has the usual laminated appearance due to dull and bright layers. Bedded impurities are inconspicuous. The chief irregularities in the coal are the clay veins ("horsebacks"). They vary in width, the maximum being about 6 feet, and consist of gray or white clay in which coal and limestone fragments are embedded.

Character of the roof and floor: The roof is black shale, 2 to 4 feet thick. The cap-rock when present varies in thickness, but is not more than 18 inches generally. The coal rests on underclay. It is reported that the clay beneath the horsebacks is harder and more pyritic than it is elsewhere.

SPRINGFIELD DISTRICT COAL MINING COMPANY'S MINE NO. 55, AT SPRINGFIELD

Entrance: Shaft; 250 feet to the top of No. 5 coal.

Thickness of the coal: Varies from 5 feet 9 inches to 6 feet 3 inches: averages 5 feet 11 inches.

Character of the coal: No unusual features noted. Horsebacks are common and these commonly show a downward bending of the coal laminae on the side of the downthrow. The downthrow of one clay vein amounted to 13½ inches, and of another, 15 inches. At a number of slips, a slight upward bending of the coal at the bottom of the bed opposite the downthrow side is evident. In general the more nearly vertical the "horseback," the less the displacement of the coal on either side.

Character of the roof and floor: The shale which forms the roof varies in thickness from 2½ to 4 feet. The limestone cap-rock present in some places is commonly 3 to 6 inches thick. Gray soapstone overlies the cap-rock. Locally a 2- to 10-inch bed of pyrite-bearing limestone containing numerous fossils lies between the black shale and the coal. The floor is underclay.

BISSELL COAL COMPANY'S MINE AT BISSELL[1]

Entrance: Shaft; about 235 feet to No. 5 coal.

Thickness of the coal: Two measurements of the coal in this mine show a thickness of 5 feet 9 inches and 6 feet 1½ inches, respectively.

Character of the coal: "Horsebacks" are common, and thin pyrite lenses are present in small amount in the middle of the bed.

Character of the roof: The roof is black shale 1½ to 4 feet thick, with locally a pyrite band ⅓ to 1 inch thick between the coal and the "slate." "Niggerheads" are not common. The cap-rock varies from 2 inches to 4 feet in thickness.

UNION FUEL COMPANY'S MINE NO. 2, AT KEYS

Entrance: Shaft; 220 feet to the top of No. 5 coal.

Thickness of the coal: Average thickness between 5½ and 5⅔ feet.

Character of the coal: The upper 2 feet of the bed is said to furnish the best coal; the next foot carries thin streaks of pyrite, and the lower coal is good. The main cleat is northeast-southwest, and the bed dips mainly to the southwest. On the extreme east, however, there is an eastward dip. The coal is cut by "horsebacks."

Character of the roof: The roof is black "slate,'' 1 foot 2 inches to 5 feet thick, with a cap-rock present in places and varying in thickness up to about 1 foot.

UNION FUEL COMPANY'S MINE NO. 5, AT SELBYTOWN

Entrance: Shaft; 267 feet to the top of No. 5 coal.

Thickness of the coal: Average, 5 feet 8 inches.

Character of the coal: The coal has a cleat which is directed near east and west. "Horsebacks" are not numerous.

Character of the roof and floor: The roof is black shale or "slate" with an average thickness of 3 feet but varying from 6 inches to 4½ feet. It is reported to make a good roof and to have but few "niggerheads." The limestone cap-rock is from 4 inches to 2 feet thick. The floor is fire clay 2½ feet or more in thickness, which heaves considerably.

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[1] Formerly Standard Washed Coal Company, Mine No. 2.

SCHUYLER COUNTY

PRODUCTION AND MINES

Mining operations in Schuyler County are all by nonshipping (or wagon) mines, and are confined to two beds, No. 2 and No. 5, of which probably No. 2 is the more important. During the year ending June 30, 1920, there were 28 local mines in the county which produced a total of 17,737 tons. Five of these, all in the vicinity of Rushville, produced between 1,000 and 4,200 tons, and according to the mining inspector's reports, it is only in this vicinity that No. 5 coal is worked in Schuyler County.

COAL-BEARING ROCKS

Schuyler County is included within the area of District III as well as IV and, because of the larger area underlain by the No. 2 coal, as compared with the area underlain by No. 5 coal, will be discussed in greater detail in the report on District III than in this report. No. 5 coal underlies only the uplands near Rushville, for the most part in T. 2 N., R. 1 W., and the eastern part of T. 2 N., R. 2 W. In all cases it is worked by shaft, slope, or drift, and so far as known it has never been stripped to any extent in this region, though there are possibly

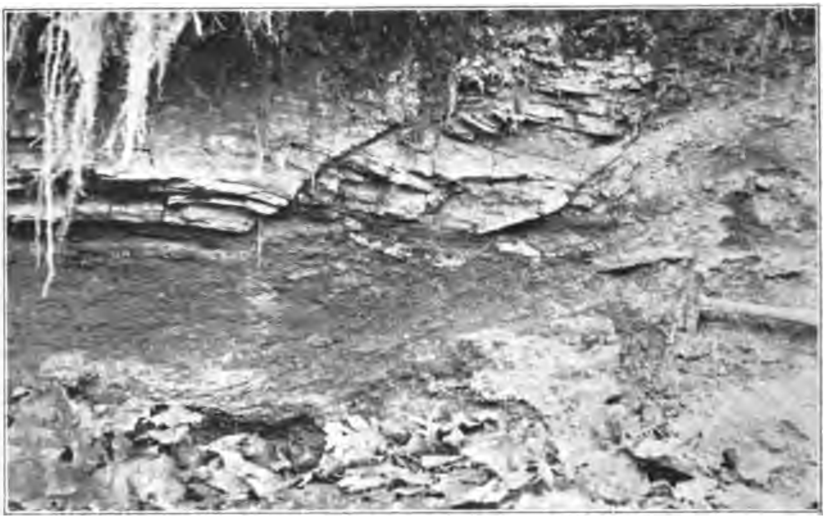

FIG. 29.—Photograph of No. 5 coal in outcrop northeast of Rushville, near the center of sec. 23, T. 2 N., R. 1 W.; the bed is cut by a small fault and a nearby "horseback."

areas where it is under too light a cover to permit use of any other method.

Between No. 5 and No. 2 coals, Worthen reports an interval of 175 to 200 feet northeast of Pleasant View. Of these strata possibly the most conspicuous is a heavy sandstone and sandy shale member which is well exposed along the Chicago, Burlington and Quincy Railroad between Rushville and Ray, beginning a few feet below No. 5 coal and having a thickness of about 100 feet.

COALS

NO. 5 COAL

The upper or No. 5 coal in Schuyler County, outcrops near Rushville, with a thickness of 4 to 6 feet, and has the usual black shale roof with "niggerheads" and limestone cap-rock, and is cut by "clay veins" or horsebacks. A photograph of one of these "horsebacks" as seen in an outcrop northeast of Rushville is reproduced as figure 29. So far as known the coal partakes of all its usual characteristics displayed in Fulton County.

NO. 2 COAL

No. 2 coal is widespread at a uniform thickness in Schuyler County except where it has been eroded along streams. A map presented in Bulletin 31 of the State Geological Survey[1] indicates a general southward dip of the coal from 580 near Littleton to 510 at Frederick and near Ripley. Assuming a constant interval between coals No. 2 and No. 5 over the county, the altitude of the upper coal should vary from about 750 to 680 feet from north to south. As the surface altitude in Schuyler County rarely exceeds 700 feet, and as the surface of bed rock is somewhat lower on account of the cover of glacial drift, it is obvious that the upper coal can be present only in the southern part of the county.

The dip is not regular to the south but is interrupted by local anticlines and synclines which bring the coal above or below the level that might be expected on the basis of a perfectly regular dip.

For a more detailed account of No. 2 coal in Schuyler County the reader must await a later bulletin on coal resources of District III.

NO. 1 COAL

No. 1 coal is known to have a local distribution in the eastern part of the county. It is not being worked, however, so far as is known. Whenever seen it was thin, 18 inches to 2 feet, and in one area in two beds, each about 2 feet in thickness. This coal as well as No. 2 will be described in greater detail in a later report.

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[1] Morse, W. C., and Kay, Fred H., The area south of the Colmar oil field: Illinois State Geological Survey Bull. 31, Plate I, 1914.

TAZEWELL COUNTY

PRODUCTION AND MINES

Production in tons, year ending June 30, 1920...............721,288
Average production 1916-1920, inclusive....................531,272

The production of coal from Tazewell County for the year ending June 30, 1920, was a little less than one per cent of the total production for the State and the county ranked twentieth. Six shipping mines and four local mines operated in that year. The names of the six shipping mines together with their production are given in Table 6.

SURFICIAL DEPOSITS

A large part of the surface of Tazewell County is morainic, and beneath the ridges of glacial material the drift is commonly thick. For instance, the preceding record of a drilling at Washington shows a depth to the rock of 335 feet 11 inches. It will be noted also that the unconsolidated material includes several water-bearing sandy horizons described as "quicksand." This record is probably representative of the more unfavorable conditions for exploration and development work that exist in the county, as it is not probable that a much greater thickness than 335 feet is generally present.

COAL-BEARING ROCKS

The coal bearing rocks of Tazewell County include strata of the Pennsylvanian system from the base up to some horizon above No. 7 coal but probably below the Lonsdale limestone. The youngest rocks in the county are adjacent to the Illinois from near Farm Creek to 5 or 6 miles south of Pekin. The slope of the rock surface is apparently eastward from this area, wherein it is at a relatively high altitude, and is sufficient so that the rock surface passes below the horizon of No. 5 coal. The rock surface also slopes to the north from this area wherein it is relatively high so that the surface of the rock passes below the bed of Farm Creek, the slope to the north accordingly being more abrupt than that to the east. It is probable that the rock surface in the northern part of the county is largely below the horizon of No. 5 coal. It appears, therefore, from the evidence at hand, that there is only a small area of rocks of the McLeansboro formation in the western part of the county, the greater part of the county being underlain by Pennsylvanian rocks belonging to the Carbondale and Pottsville formations.

Record of drilling in NE. cor. sec 23, T. 26 N., R. 3 W., near Washington, Illinois.

Altitude: Est. 745 feet.

Description of Strata	Thickness		Depth	
Quaternary system—				
Pleistocene and Recent—	*Ft.*	*in.*	*Ft.*	*in.*
Clay and loam	3	....	3	....
Gravel	83	....	86	....
Clay	24	....	110	....
Clay and gravel	20	....	130	....
Clay, light blue	15	....	145	....
Gravel	31	....	176	....
Clay	6	....	182	....
Gravel	7	....	189	....
Clay and gravel	10	....	199	....
Clay, light blue	8	....	207	....
Gravel	11	8	218	8
Sand	9	....	227	8
Quicksand	23	....	250	8
Gravel	7	....	257	8
Quicksand, gray	7	....	264	8
Quicksand, white	69	....	333	8
Gravel	2	3	335	11
Pennsylvanian system—				
Soapstone, light	25	....	360	11
Sandstone, light	15	....	375	11
"Slate," black	8	....	383	11
Coal	....	6	384	5
Fire clay	4	....	388	5
"Slate," light gray	26	....	414	5
"Slate," dark	17	6	431	11
"Slate," black	11	4	443	3
Coal (No. 2?)	3	8	446	11
Fire clay	3	....	449	11
"Slate"	8	9	458	8

Record of drilling about 6½ miles southeast of Pekin, Illinois.

Description of strata	Thickness *Feet*	Depth *Feet*
Quaternary system—		
Pleistocene and Recent—		
Clay, yellow	16	16
Clay, blue	140	156
Sand and gravel; some gas	10	166
Pennsylvanian system—		
Shale, dark	119	285
Fire clay	4	289
Shale, black	71	360
Shale, white	40	400
Shale, dark	20	420
Shale, white	45	465
Shale, dark	3	468
Coal (No. 2?)	4	472
Fire clay	9	481
Shale, white	34	515
Fire clay	4	519
Shale, white	84	603
Shale, dark	104	707
Sandstone	1	708
Shale, white	29	737
Sandstone	5	742
Limestone, blue	3	745
Sandstone	4	749
Limestone	2	751
Sandstone	3	754
Limestone	3	757

The operations in Tazewell County are all along or near the Illinois valley, where conditions are essentially the same as those described for Peoria County. The eastern part of the county is heavily drift covered, and rock exposures are very uncommon if they exist at all. So little drilling has been deep enough to penetrate the coal-bearing strata that except for a narrow strip between Pekin and East Peoria, the distribution and thickness of the coal beds is practically unknown in this county. There is little doubt, however, that No. 2 coal is widespread throughout the county in workable thickness, and probably No. 5 coal is also present in large areas.

Neither of these records gives sufficient detail to permit the accurate correlation of the coals. In one record the coal at a depth of 443 feet is considered as probably No. 2, since it is obviously too deep for No. 5. No. 2 coal lies about 150 feet below No. 5 in the Peoria region. The latter has an average altitude of 431 feet in Pekin Township. Thus No. 2 would have an altitude of about 290 feet. In the second record given above, the surface altitude is about 680 feet and that of the coal correlated as No. 2 is 208 feet. This is lower than the average altitude for the coal noted above, but the difference may be accounted for by the eastward dip of the rocks. The upper coal, No. 5, was apparently missed in drilling this hole, whereas in the hole near Washington it has apparently been eroded, the base of the drift lying below the horizon of the coal.

POTTSVILLE FORMATION

Concerning the character of the Pottsville formation in this county the only available information is that afforded by several water well records near Pekin and East Peoria, supplemented by data concerning the strata in the eastern part of Peoria County. It is unnecessary to repeat the description of the formation as given for Peoria County. It may be pointed out, however, that near Peoria in the Pottstown mine, one workable coal lies 110 to 130 feet below No. 2 coal. This coal lies in two benches separated by nearly 3 feet of shale, the upper bench 1 foot 3 inches and the lower bench 2 feet 3 inches in thickness. It is thought to be the No. 1 coal of the Illinois coal, which has been mined extensively in the Rock Island region and in the mine at Parrville, Fulton County. Although this coal is too thin to be mined profitably at present, it represents a valuable resource which must be drawn upon some day.

Between No. 1 and No. 2 coals there are possibly two coals of workable thickness, one 30 to 40 feet above No. 1 coal and the other about the same distance below No. 2 coal. The lower of these coals in some of the wells drilled in the Peoria district was reported to be about 30 inches in thickness, and the other between 1 and 2 feet. It is physically possible to mine coals 18 inches thick, with the proper equipment, at a cost not greatly exceeding the cost of mining the thinnest of the coals now mined in the State. Eventually after the supply of thicker coal has been exhausted, these thin beds will doubtless be worked.

CARBONDALE FORMATION

At the base of the Carbondale formation lies No. 2 coal, which is very probably widespread in this county, and has a thickness of about 3 feet. It is present at Pekin and East Peoria and at Washington, and in the surrounding counties, and lies nearly level throughout a large area east of the Illinois. There is only about 50 feet difference in the altitude of this coal at Pekin, at Bloomington, and at Washington. This coal commonly has a "soapstone" or gray shale roof up to about 20 feet in thickness with a 3-foot black paper-shale overlying the soapstone. The roof is especially adapted to the longwall method of mining which is employed in all cases where this seam is worked.

The details of the succession between this coal and No. 5 are not known. In surrounding counties the strata consist largely of shale with massive sandstone near the top of the section not uncommonly. The interval between these two coals in the Peoria region varies from 110 to 140 feet, and at Bloomington it is 130 feet, or essentially the same as at Peoria. It is not improbable, therefore, that the thicknesses and succession of strata are about the same in the intermediate region which includes Tazewell County. Details of the succession can be learned by reference to the chapters on McLean and Peoria counties.

No. 5 coal, which underlies at least the western part of the county in the vicinity of East Peoria and Pekin, and probably extends as far east as Groveland, varies in thickness from about 4 feet 4 inches at the north to about 4 feet 8 to 10 inches to the south. It has the usual characteristics of No. 5 coal; that is, it does not lie in benches, is characteristically cut by clay veins and by pyrite-filled veins ("spars"), and contains banded brown or gray pyrite and a few bright pyrite balls in the upper part of the bed. Within the area of its outcrop along the bluff and beneath the drift it is fairly continuous, but in places is interrupted by "faults" which are interpreted as channel sandstone just as are the "faults" on the Peoria side of the river. Just northeast and south of its outcrop the coal is apt to be affected by preglacial or glacial erosion, so that considerable areas may not be minable. Development work in this county and in this coal bed should be preceded by careful exploration by the drill.

The strata overlying No. 5 coal vary from the usual black slate, clod cap-rock, and gray-shale succession to sandstone. Especially in Groveland Township sandstone is apparently at no place a great distance above the coal, and locally cuts down into the black shale and rests upon the coal. In the vicinity of Wesley the sandstone in places cuts out the coal entirely, just as it does in Hollis Township in Peoria County.

The section between No. 5 and No. 6 coals is composed largely of sandstone and sandy shale, the interval between the two coals being about 60 feet.

No. 6 coal in western Tazewell County is irregular in thickness. As shown by the following sections[1] it is in some places over 4 feet and in others less than 1½ feet.

---

[1] Udden, J. A., Geology and mineral resources of the Peoria quadrangle, Ill.: U. S. Geological Survey Bull. 506, pp. 45-46, 1912.

Section in the north bank of creek, one-fourth mile southwest of the NE. cor. sec. 24, Pekin Township

	Thickness Ft.	in.
Shale, light gray	1	..
Limestone, thinning rapidly to east	2	..
Shale, "white top"	..	6
Coal, thinning rapidly to east (No. 6)	1	6
Fire clay	3	..
Shale, arenaceous	15	..
	23	..

Section in west bank of Lick Creek, near junction of its two forks, Sec. 25, Pekin Township

	Thickness Ft.	in.
Sandstone	4	..
Sandstone, shaly	6	..
Limestone, discontinuous	1	..
Shale, "white top"	1	6
Coal, No. 6	2	6
Fire clay, with dark ferruginous band near middle	3	6
Shale, gray	2	6
Sandstone in somewhat shattered beds	3	..
Shale, light bluish-gray, arenaceous	23	..
	47	..

Section in west bank of Lick Creek, near wagon bridge, in NW. cor. Sec. 31, Groveland Township

	Thickness Ft.	in.
Shale, light gray	6	..
Clay, structureless residuum firm	1	2
Shale, dark fissile, with gray discontinuous laminations	1	..
Coal	2	9
Clay	..	2
Coal, with lenses of pyrite near middle	1	6
Fire clay, greenish gray	4	..
	16	7

Careful drilling in the area underlain by No. 6 coal may discover areas in which the coal is as much as 4 feet thick. However, just as in southern Peoria County, this coal very commonly is overlain by a loose, incoherent, grayish shale called "white top" which is very hard to hold and which makes mining very expensive, and also cuts out a considerable proportion of the bed. The "white top" roof has been described in greater detail in the discussion of the coal resources of Peoria County.

MC LEANSBORO FORMATION

So far as known, the rocks of the McLeansboro formation are restricted in this county to a small area between Pekin and East Peoria. They include No. 7 coal, which has a thickness of 14 to 18 inches and lies about 30 to 35 feet above No. 6 coal.

The lower part of the formation which constitutes the roof of No. 6 coal is normally dark fissile shale, 1 to 3 feet thick, or gray shale called "white top." Commonly the black or gray shale is overlain by limestone cap-rock, 1 to 4 or 5 feet in thickness. Marly or calcareous shale overlies the limestone and grades upward into sandy shale or sandstone, which continues nearly to No. 7 coal. No. 7 coal is underlain by a few feet of underclay and shale.

The McLeansboro formation seems to have been eroded down to some horizon below the Lonsdale limestone, which lies near the top of the section on the west side of the river.

Minable Coals of Tazewell County

The coals in Tazewell County which at present are of commercial importance are probably only No. 2 and No. 5, and of these only No. 5 is being worked. Very little is known about No. 2, but its persistence throughout the northern part of the State is a basis for inferring its presence in this area. No. 7 coal is apparently too thin to mine at present and No. 6 unsatisfactory because of its irregular character and poor roof. Any statement in regard to the occurrence and distribution of No. 1 coal and the possible existence of coals between No. 1 and No. 2 is pure speculation. It follows, therefore, that interest is mainly in No. 2 and No. 5 coals.

NO. 2 COAL

No. 2 coal is mined extensively in the Longwall District and is found in the northern and central portions of the Illinois coal field wherever shafts or bore holes have been sunk to its horizon. Commonly the seam is about 30 inches thick, with a good soapstone roof, which is excellently suited for Longwall methods of mining. As a rule it has no seriously detrimental impurities and is of slightly better quality than higher beds in the same locality. It is believed that this coal is generally present in this county, but it has never been worked.

NO. 5 COAL

There are several operations in No. 5 coal in Tazewell County along the bluff of the Illinois between East Peoria and Pekin. The coal has the same general characteristics as the seam in the Peoria district, described in the section on that county. The distribution of the coal is limited on the west by the Illinois valley, and in the other directions by pre-glacial or interglacial erosion. The rock surface slopes rather abruptly to the north at Farm Creek, so that it probably passes below the level of the coal; and although it slopes somewhat less abruptly to the east and south, still the grade is sufficient to cause the rock surface of the central and eastern parts of the county also to be probably largely below the horizon of No. 5 coal.

The coal in the East Peoria region is locally interrupted by sandstone "faults" especially in the vicinity of Wesley. These sandstone "faults" are thought by the writer to be the filling of channels cut into the peat deposit shortly after its deposition. In part of the area this same body of sandstone lies but a short distance above the coal, the base of it forming the roof of the coal in the places where the shale roof which is generally present has been eroded.

MINE NOTES

The following detailed description of conditions in a few of the Tazewell County mines will serve to set forth the general character of the coal and of the mining conditions in this area.

GROVELAND COAL MINING COMPANY'S MINE NO. 1, AT EAST PEORIA

Entrance: Shaft; depth to No. 5 coal, 85 feet.

Thickness of coal: Varies from 3 feet to 4 feet 8 inches; averages 4 feet 4 inches.

Sections of the coal:

Sections of No. 5 coal in Mine No. 1 of the Groveland Coal Mining Company

Section 1—Room 1 off 3d stub off the 6th east entry

	Thickness	
	Ft.	*in.*
Roof: Black fissile shale	..	..
Coal with thin streaks of clay and mother coal	4	3
Floor: Underclay	..	..
	4	3

Section 2—Room 6 off the 10th east entry

	Thickness	
	Ft.	*in.*
Coal	1	5
Pyrite (brown "sulphur")	..	1¾
Coal	2	10¼
	4	5

Character of the coal: The coal lies as a single bench without persistent partings. The thin bands of clay and mother coal, generally present in the face, are rarely more than ¼ inch in thickness, are not persistent at any one place, and not very important as impurities. On the east side of the mine pyrite bands of "brown sulphur" are commonly found near the horsebacks. These are generally about 1½ inches thick and may be 4 to 5 feet in length. They appear to be intimate interlaminations of pyrite and carbonaceous material.

The coal is practically uniform in thickness, the only departures from uniformity being near the "horsebacks" or clay slips. Where these fractures occur the coal is usually slightly displaced, the bed on one side of the fracture being somewhat lower than it is on the other (see fig. 30).

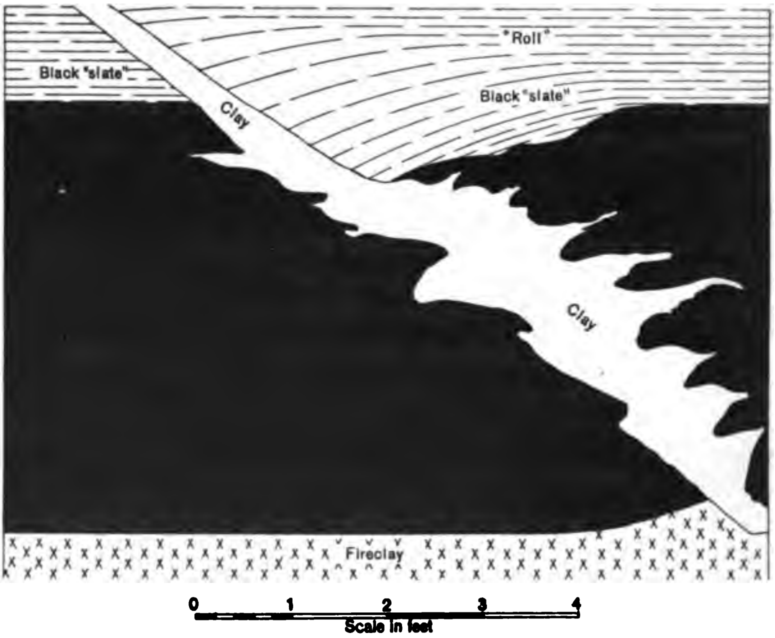

FIG 30.—Sketch of a "horseback" in No. 5 coal in the Groveland Coal Mining Company's No. 1 mine at East Peoria.

Commonly the fracture is at a fairly acute angle with the horizon of the bed, so that the roof on the downthrow side is much nearer the floor than under normal conditions. Similarly, the floor on the opposite side of the fracture is nearer the roof than usual. However, the floor does not commonly rise as high as the roof is down-faulted, there apparently being some compensation either in the coal or in the adjacent strata. These phenomena in the roof and floor are spoken of as "rolls."

The coal on the east side of the mine is badly fractured, but the fractures are not so generally filled with clay as they are elsewhere. Instead, pyrite-filled cracks, called "spar" by miners, are the common thing. Although rarely more than ¼ inch thick, they are very hard to drill so that the miners do not like to work in the part of the mine where they are common. Furthermore, there are cracks ("blind slips") which penetrate the coal and pass up into the roof but in a fresh face are not discernable, and which produce an extremely treacherous roof that is practically impossible to control.

Character of the roof: Incidental to the preceding description of the coal some mention has been made of certain difficulties encountered in the roof of this mine. Other characteristics may be mentioned.

The massive sandstone which lies a short distance above the coal throughout much of this area as well as the area south of Peoria on the west side of the Illinois, is exposed above the coal in a number of places in this mine. The sandstone has a very irregular base and accordingly lies at various heights above the coal, in places very close to the bed or even resting on it. Apparently there are no places where the sandstone cuts out the coal, though this condition is reported to have existed in an old mine a short distance to the north.

The usual roof is black shale, 8 to 14 inches thick, with clod and limestone above. The lower 2 inches of black shale or "slate" is called "draw slate." This is commonly "frozen" to the coal. The break that takes place in mining near the top of the bed commonly occurs an inch or two below the slate. If the break occurs in the slate so that the "draw slate" parts from the overlying shale, the material that is left lacks coherence and is difficult to keep. In this mine when the "draw slate" comes down it is soon followed by all the rest of the material up to the sandstone. In some localities in the mine this means as much as 20 feet of material.

The so-called cap-rock is a layer of fossiliferous gray limestone 2 to 8 inches thick which in places is hard but more commonly is shaly, with no supporting strength. The clod lying between the black shale and the "cap-rock" is a massive, dark gray, loosely coherent shale, about 14 inches thick, that falls readily. Overlying the cap-rock is a gray shale which continues up to the sandstone a distance of about 18 feet or less.

Character of the floor: The floor is underclay. No unusual characteristics other than the rolls associated with the horsebacks were noted.

JOHNSTON CITY BIG MUDDY COAL AND MINING COMPANY'S NO. 3 MINE, AT PEKIN.

Entrance: Shaft; depth to the top of No. 5 coal 205 feet.

Thickness of coal: Reported to average 4 feet 8 inches.

Character of the coal: The following description is based upon information obtained from the mine manager. The coal has not been seen by a Survey member.

The coal lies in a single bed, without benches. The few discontinuous bands of "sulphur" near the horsebacks and the little hard pyrite balls and lenses, are said to be too infrequent to seriously damage the coal. Horsebacks are fairly numerous and their removal entails considerable waste.

Character of the roof: The roof succession consists of 6 to 12 inches of black shale, called "slate," which sticks to the coal so that presumably either a few inches of coal is left in the roof or some of the shale comes down with the coal. Above the black shale is about 12 inches of clod, above which there is commonly 6 to 8 inches of limestone. This, however, is locally absent. A thick bed of shale overlies the limestone.

Character of the floor: Underclay about 18 inches thick. Below the clay is 12 inches of limestone which in turn is underlain by more clay.

The general characteristics of the coal in this mine are probably very similar to those of the coal in the Tazewell Coal Company's mine which is operated on an adjacent property.

TAZEWELL COAL COMPANY'S MINE NO. 1, AT PEKIN

Entrance: Shaft; 162 feet to the top of No. 5 coal.

Thickness of coal: Varies from about 4 feet to about 4 feet 10 inches; averages 4 feet 8 inches.

Sections of the coal:

Sections of No. 5 coal in mine of the Tazewell Coal Company

Section 1—Face of second entry off main south

	Thickness	
	Ft.	*in.*
Roof: Black slate	..	..
Coal, fairly clean	1	5¾
Pyrite	..	¼
Coal, clean and bright	1	11½
Bone	..	½
Coal, fairly clean	..	9
	4	3

Section 2—Face of room 5, 1st stub, 12th east off south entry

	Thickness	
	Ft.	*in.*
Roof: Black shale	..	..
Coal, left up	..	3 to 4
Coal, clean	..	1¼
Mother coal and pyrite	..	¾
Coal, very dirty	4	1
Floor: Underclay	..	..
	4	6

Section 3—Face of room 16, first stub east, 8th south off east entry

	Thickness	
	Ft.	*in.*
Roof: Black slate	..	..
Coal, slean, bright	1	2½
Pyrite lens	..	2½
Coal, clean, bright	..	8
Mother coal, soft	..	½
Coal, fairly clean and bright	2	3½
Floor: Underclay	..	..
	4	5

Character of the coal: The coal lies in a single bed with no benches, but contains discontinuous streaks of clay and mother coal, and near the horsebacks or clay slips lenses of pyrite are common. There is some calcite along the joints faces. "Horsebacks" are numerous and commonly so impregnated with pyrite that they are very hard. Fig. 31 is a reproduction of a sketch of a horseback. It will be observed that the clay vein plays out in the overlying shale into a number of cracks and that the underclay has been squeezed a short distance upward into the fracture. At the veins the cap-rock commonly shows a slight displacement. The side of the fracture in the coal is generally irregular, but also commonly shows "smooths" or slickensides.

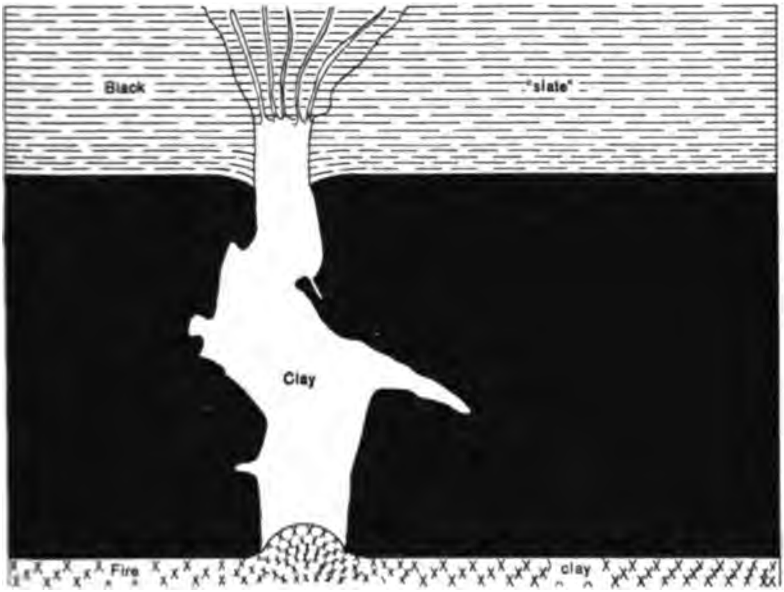

Fig. 31.—Sketch of a "horseback" in No. 5 coal in the Tazewell Coal Company's No. 1 mine at Pekin.

Character of the roof: The immediate roof is dark shale or "slate," 8 to 12 inches thick, which commonly sticks to the coal, so that either the upper 2 or 3 inches of coal is left up or the lower 2 or 3 inches or more of the shale comes away with the coal. This makes no particular difficulty. About 12 inches of clod lies between the black shale and the cap-rock. The latter is a limestone which is solid only locally and then is about 8 inches thick.

Character of the floor: The underclay is about 12 inches thick. It becomes hard 12 inches below the coal, but the upper part heaves badly in the air, and especially when it is wet.

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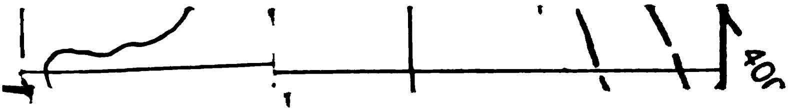
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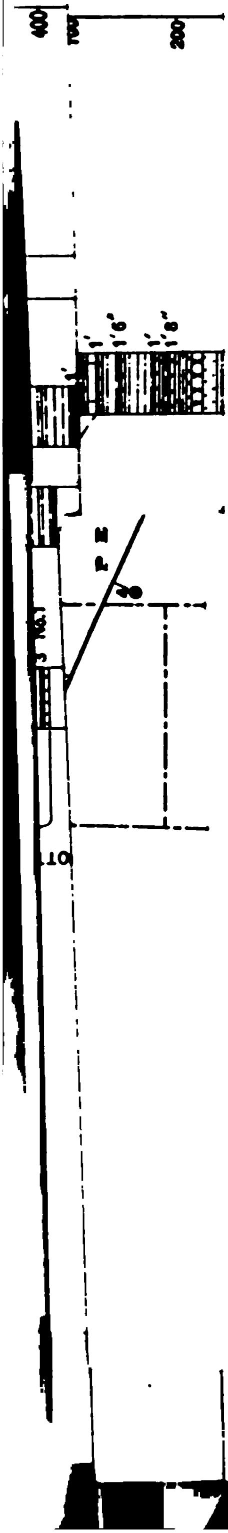
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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE GEOLOGICAL SURVEY
FRANK W. DE WOLF, Chief

Cooperative Mining Series

EXTRACT FROM BULLETIN No. 27

ANALYSES OF ILLINOIS COALS

COMPILED BY

G. W. HAWLEY

ILLINOIS MINING INVESTIGATIONS

Prepared under a cooperative agreement between the Illinois State Geological Survey Division, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines

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ANALYSES OF ILLINOIS COALS

Compiled by G. W. Hawley

INTRODUCTION

A study of the chemical character of Illinois coals based on new face samples collected in 1921 from approximately 100 mines in various parts of the State was begun with a view to extending our knowledge of the chemical properties, heating quality, and special adaptability of all Illinois coals. A bulletin will be issued at an early date which will present the conclusions based on these data, but it seems desirable to publish the analytical data prior to the complete report. The analyses have been combined with data previously published by the State Geological Survey[1] [2] and also by the United States Bureau of Mines. References to the bulletins in which the analytical results of coal samples collected by the United States Bureau of Mines have been published, are indicated throughout the tables of analyses in order that the detailed descriptions of the samples may be consulted.

ANALYTICAL DATA

Analyses of Mine Samples

Table 1, which gives an alphabetical list of counties including the district classification (see fig. 1) and the coal beds for each county, serves as a cross reference.

The complete analyses of mine samples grouped by coal beds, under which the counties represented are arranged alphabetically, are given in Table 2. Analyses having the same index number are of samples for a single mine. Obviously, not as much dependence can be placed on a single analysis from a given mine as may be placed on a group from one mine. Two sets of values are given for each sample—one including the normal or coal-bed moisture, and the other calculated to the dry-coal or moisture-free basis. There is also given the value of the unit-coal in British thermal units as derived by the formula previously explained[2].

---

[1] Parr, S. W., Chemical study of Illinois coals: Ill. Mining Investigations Bull. 3, 1916.

[2] Parr, S. W., Purchase and sale of Illinois coal on specification: Ill. State Geol. Surv. Bull. 29, 1914.

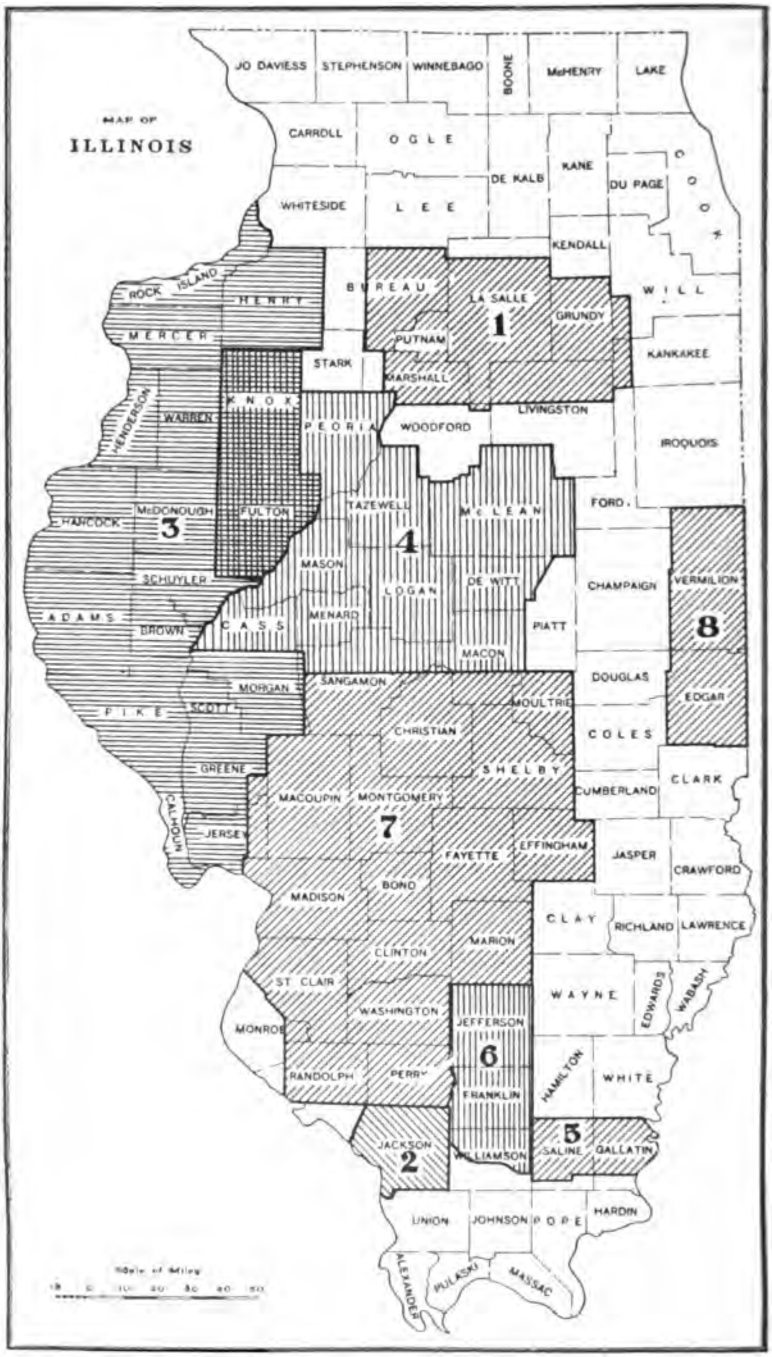

Fig. 1.—Districts for classification of coal samples

In Table 3 are presented the average analyses and heat values for separate mines and by counties grouped according to the districts shown in figure 1.

TABLE 1.—*Alphabetical arrangement of counties.*

County	Coal bed	District	County	Coal bed	District
Bond	6	VII	McLean	2, 5	IV
Bureau	2	I	Menard	5	IV
Calhoun	2	III	Mercer	1	III
Christian	1, 2, 6	IV, VII	Montgomery	6	VII
Clinton	6	VII	Moultrie	6	VII
Franklin	6	VI	Peoria	5	IV
Fulton	1, 5	III, IV	Perry	6	VI, VII
Gallatin	5, 6	V	Randolph	6	VII
Grundy	2	I	St. Clair	6	VII
Jackson	2, 6	II, VI	Saline	5	V
LaSalle	2, 5, 7	I	Sangamon	5, 6	IV, VII
Livingston	2, 5	I	Schuyler	1, 2	III
Logan	5	IV	Shelby	6	VII
Macon	5	IV	Tazewell	5	IV
Macoupin	6	VII	Vermilion	6, 7	VIII
Madison	6	VII	Washington	6	VII
Marion	6	VII	White	6	V
Marshall	2	I	Williamson	6	VI
McDonough	2	III			

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output).*

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
					No. 1 Coal.							
5229	21	7/12	Christian	1	11.27 Dry	38.68 43.58	40.55 45.70	9.50 10.71	2.07 2.33	.33 .37	11445 12898	 14686
5230	21	7/12	Christian	1	11.52 Dry	38.73 43.83	41.01 46.35	8.69 9.82	2.42 2.73	.97 1.10	11648 13163	 14707
5231	21	7/12	Christian	1	11.13 Dry	39.21 44.12	41.26 46.43	8.40 9.45	2.56 2.88	.61 .69	11715 13183	 14779
12469	106	3/21	Fulton	1	11.38 Dry	38.66 43.62	39.51 44.58	10.45 11.80	4.52 5.10	.87 .98	11436 12905	 14979
12470	106	3/21	Fulton	1	11.42 Dry	38.17 43.09	40.07 45.24	10.34 11.67	4.76 5.37	.45 .51	11409 12880	 14934
12471	106	3/21	Fulton	1	10.84 Dry	38.42 43.09	40.91 45.88	9.83 11.03	5.61 6.29	.54 .61	11554 12959	 14939
5338	19	8/12	Mercer	1	13.23 Dry	40.29 46.43	37.20 42.88	9.28 10.69	4.37 5.04	.41 .47	11104 12797	 14641
5339	19	8/12	Mercer	1	15.24 Dry	37.66 44.44	35.73 42.15	11.37 13.41	4.80 5.66	1.47 1.73	10353 12214	 14478
5340	19	8/12	Mercer	1	15.15 Dry	39.06 44.44	38.48 42.15	7.31 14.41	3.30 5.66	.17 1.73	11252 12214	 14478
5363	19	8/12	Mercer	1	14.97 Dry	38.27 46.03	37.07 45.36	9.69 8.61	3.75 3.89	.33 .19	9637 13260	 14760
5364	19	8/12	Mercer	1	14.46 Dry	40.42 44.99	35.33 43.61	9.79 11.40	4.23 4.95	.69 .43	10780 12749	 14712
5365	19	8/12	Mercer	1	14.07 Dry	39.95 47.24	34.01 41.32	11.97 11.44	4.55 4.94	.78 .59	10525 12603	 14551
5359	18	8/12	Mercer	1	14.58 Dry	39.49 46.49	36.82 39.59	9.11 13.92	5.00 5.29	.15 .91	10894 12247	 14604
5360	18	8/12	Mercer	1	15.07 Dry	38.14 46.23	37.44 43.09	9.35 10.68	4.85 6.56	.34 .18	10790 12754	 14642
5361	18	8/12	Mercer	1	14.10 Dry	39.60 44.91	36.73 44.01	9.57 11.02	3.92 5.71	.23 .38	10956 12705	 14618
5371	17	8/12	Mercer	1	17.75 Dry	39.50 48.03	34.61 42.08	8.14 9.89	5.53 6.72	.86 1.05	10435 12687	 14373
5372	17	8/12	Mercer	1	17.50 Dry	38.78 47.00	33.66 40.80	10.06 12.20	4.51 5.46	.29 .35	10238 12409	 14372
					No. 2 Coal.							
5324	1	8/12	Bureau	2	16.65 Dry	36.66 43.99	38.58 46.29	8.11 9.72	3.40 4.07	.67 .80	10740 12884	 14533
5325	1	8/12	Bureau	2	15.08 Dry	40.12 47.25	36.35 42.80	8.45 9.95	3.68 4.33	.91 1.07	10831 12754	 14431
5326	1	8/12	Bureau	2	16.83 Dry	36.54 43.93	39.19 47.12	7.44 8.95	2.64 3.17	.89 1.07	10788 12970	 14463
5312	10	8/12	Bureau	2	14.88 Dry	38.69 45.45	37.25 43.76	9.08 10.79	3.83 4.50	1.07 1.25	10685 12553	 14357

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5313	10	8/12	Bureau.........	2	17.43	38.07	39.44	5.06	2.68	.52	11070	......
					Dry	46.10	47.76	6.14	3.25	.63	13407	14462
5314	10	8/12	Bureau.........	2	16.07	39.68	38.36	5.89	2.96	.57	11216	......
					Dry	47.28	45.71	7.01	3.53	.63	13363	14571
5348	8	8/12	Bureau.........	2	15.19	39.67	38.69	6.45	2.20	.99	11206	......
					Dry	46.78	45.60	7.62	2.62	1.17	13213	14480
5349	8	8/12	Bureau.........	2	17.34	37.12	39.28	6.26	2.80	.49	11006	......
					Dry	44.90	47.52	7.58	3.38	.59	13314	14612
5350	8	8/12	Bureau.........	2	16.97	38.66	34.83	9.54	2.25	2.29	10397	......
					Dry	46.56	41.95	11.49	2.71	2.91	12522	14386
2641	230	7/09	Calhoun........	2	10.62	38.13	39.65	11.60	4.96	......	11224	......
					Dry	42.67	44.36	12.97	5.55	......	12557	14806
5205	21	7/12	Christian.......	2	12.07	39.36	41.91	6.66	3.74	.07	11776	......
					Dry	44.77	47.66	7.57	4.26	.09	13393	14730
5206	21	7/12	Christian......	2	12.53	38.00	40.62	8.25	3.67	.31	11389	......
					Dry	44.12	46.44	9.44	4.22	.35	13020	14641
5207	21	7/12	Christian......	2	14.30	39.54	40.30	5.86	2.00	.24	11609	......
					Dry	46.14	47.02	6.84	2.33	.28	13544	14702
5367	6	8/12	Grundy.........	2	19.97	38.16	37.45	4.42	1.82	.65	10936	......
					Dry	47.68	46.79	5.53	2.27	.79	13664	14603
5368	6	8/12	Grundy.........	2	18.95	37.60	38.23	5.22	2.46	.64	10787	......
					Dry	46.39	47.16	6.45	3.04	.79	13309	14400
5369	6	8/12	Grundy.........	2	19.66	37.01	38.16	5.17	2.03	.83	10734	......
					Dry	46.06	47.50	6.44	2.53	1.03	13360	14337
5373	5	8/12	Grundy.........	2	17.29	38.61	36.69	7.41	2.87	1.44	10708	......
					Dry	46.68	44.36	8.96	3.47	1.74	12947	14447
5374	5	8/12	Grundy.........	2	13.73	39.87	42.19	4.21	2.04	1.47	11787	......
					Dry	46.22	48.90	4.88	2.37	1.71	13662	14466
5377	5	8/12	Grundy.........	2	17.01	39.48	36.74	6.77	3.32	1.05	10834	......
					Dry	47.57	44.27	8.16	4.00	1.27	13055	14446
5375	7	8/12	Grundy.........	2	16.84	38.37	41.19	3.60	1.74	.04	11508	......
					Dry	46.13	49.53	4.34	2.09	.05	13838	14583
5376	7	8/12	Grundy.......	2	15.81	39.28	39.77	6.13	2.30	.24	11212	......
					Dry	45.48	47.24	7.28	2.73	.28	13318	14545
5378	7	8/12	Grundy.........	2	16.23	38.71	40.61	4.45	2.47	.32	11461	......
					Dry	46.22	48.47	5.31	2.94	.38	13683	14610
5225	14	7/12	Jackson.........	2	7.72	35.09	48.56	8.63	2.01	.29	12248	......
					Dry	38.02	52.62	9.36	2.18	.31	13272	14839
5226	14	7/12	Jackson.........	2	8.77	32.78	50.58	7.87	2.00	.02	12253	......
					Dry	35.93	55.44	8.63	2.19	.03	13430	14885
5228	14	7/12	Jackson.........	2	9.18	34.70	51.58	4.54	.60	.05	12752	......
					Dry	38.20	56.80	5.00	.66	.06	14040	14867
5248	13	7/12	Jackson.........	2	9.88	33.23	52.43	4.46	.70	.33	12709	......
					Dry	36.87	58.18	4.95	.77	.36	14103	14926
5249	13	7/12	Jackson.........	2	10.91	33.51	51.20	4.38	1.14	.20	12503	......
					Dry	37.61	57.47	4.92	1.28	.23	14034	14963

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5250	12	7 12	Jackson	2	9.76	33.45	52.07	4.72	1.08	.51	12629	------
					Dry	37.06	57.71	5.23	1.20	.56	13996	14874
5251	12	7 12	Jackson	2	9.51	33.13	52.12	5.24	.66	.94	12500	------
					Dry	36.62	57.59	5.79	.73	1.03	13814	14758
5252	12	7 12	Jackson	2	9.36	33.39	49.29	7.96	2.11	.94	11972	------
					Dry	36.48	54.38	8.78	2.32	1.03	13208	14671
5253	12	7 12	Jackson	2	9.89	32.51	51.98	5.62	.62	.20	12308	------
					Dry	36.12	57.63	6.25	.69	.22	13673	14686
5496	16	8 12	Jackson	2	9.25	34.67	50.53	5.55	1.41	.13	12528	------
					Dry	38.20	55.68	6.12	1.56	.14	13804	14834
5497	16	8 12	Jackson	2	9.56	34.52	50.47	5.45	1.32	.27	12483	------
					Dry	38.16	55.83	6.01	1.46	.30	13781	14811
5498	16	8 12	Jackson	2	9.20	34.48	50.54	5.78	1.44	.19	12481	------
					Dry	37.97	55.66	6.37	1.59	.21	13746	14814
5286	13	8 12	Jackson	2	8.32	35.28	51.10	5.30	1.39	.19	12671	------
					Dry	38.49	55.74	5.77	1.53	.21	13822	14791
5287	13	8 12	Jackson	2	8.86	35.00	49.74	6.40	1.69	.07	12436	------
					Dry	38.40	54.57	7.03	1.85	.08	13645	14830
5288	13	8 12	Jackson	2	8.91	34.03	53.17	3.89	1.15	.07	12844	------
					Dry	37.36	58.37	4.27	1.26	.08	14101	14823
12662	104	6 21	Jackson	2	4.56	37.90	44.23	13.31	6.62	.03	11886	------
					Dry	39.71	46.35	13.94	6.94	.03	12456	14921
12663	104	6 21	Jackson	2	4.57	34.73	46.22	14.49	7.63	.04	11670	------
					Dry	36.41	48.41	15.18	8.00	.04	12229	14934
5388	2	8 12	LaSalle	2	14.22	39.49	36.94	9.35	4.46	.80	10887	------
					Dry	46.03	43.06	10.91	5.20	.93	12691	14562
5389	2	8 12	LaSalle	2	15.16	40.13	38.10	6.61	2.98	.64	11147	------
					Dry	47.32	44.88	7.80	3.51	.70	13138	14458
5390	2	8 12	LaSalle	2	14.43	40.01	35.89	9.67	4.47	1.03	10678	------
					Dry	46.75	41.94	11.31	5.23	1.21	12476	14404
5306	3	8 12	LaSalle	2	14.29	41.35	38.73	5.63	2.09	.19	11487	------
					Dry	48.24	45.18	6.58	2.44	.22	13401	14504
5307	3	8 12	LaSalle	2	16.05	37.03	37.06	9.86	4.35	.59	10459	------
					Dry	44.11	44.16	11.73	5.18	.70	12458	14440
5311	3	8 12	LaSalle	2	14.82	40.93	35.20	9.05	3.42	.99	10760	------
					Dry	48.05	41.33	10.62	4.02	1.17	12632	14401
5351	9	8 12	LaSalle	2	16.52	38.88	36.50	8.10	2.87	1.02	10686	------
					Dry	46.57	43.72	9.71	3.44	1.22	12800	14412
5352	9	8 12	LaSalle	2	17.77	39.05	34.15	9.03	3.92	1.25	10279	------
					Dry	47.48	41.55	10.97	4.76	1.52	12500	14334
5353	9	8 12	LaSalle	2	18.06	39.02	32.94	9.98	2.74	2.20	10209	------
					Dry	47.62	40.20	12.18	3.34	2.69	12460	14460
84450	102	3 22	LaSalle	2	14.5	36.0	41.7	7.8	3.5	.67	11130	------
					Dry	42.0	48.9	9.1	4.1	.79	13010	14564
84451	102	3 22	LaSalle	2	14.0	34.9	43.2	7.9	2.3	.90	11240	------
					Dry	40.6	50.3	9.1	2.7	1.04	13070	14584

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
84452	102	3/22	LaSalle.........	2	15.7 Dry	33.9 40.2	41.9 49.7	8.5 10.1	4.0 4.8	.59 .70	10800 12800	 14528
10264	103	9/17	LaSalle.........	2	12.61 Dry	38.89 44.51	42.36 48.46	6.14 7.03	2.66 3.04	....	11892 13608	 14830
10263	103	9/17	LaSalle.........	2	12.19 Dry	39.92 45.47	40.18 45.75	7.17 8.78	2.56 2.91	....	11667 13289	 14780
1741	[1]B. M.	6/05	LaSalle.........	2	13.87 Dry	37.26 43.26	38.56 44.77	10.31 11.97	3.44 3.99	....	10985 12755	 14792
1742	[1]B. M.	6/05	LaSalle.........	2	15.55 Dry	36.21 42.88	40.66 48.14	7.58 8.98	3.01 3.56	....	....	....
1779	[1]B. M.	6/05	LaSalle.........	2	12.39 Dry	36.89 42.11	41.80 47.71	8.92 10.18	3.92 4.47	....	11399 13012	 14743
5357	4	8/12	Marshall.......	2	16.46 Dry	38.48 46.06	38.27 45.80	6.79 8.14	2.91 3.48	.28 .34	11162 13360	 14764
5356	4	8/12	Marshall.......	2	16.79 Dry	36.81 44.23	40.34 48.49	6.06 7.28	2.59 3.11	.41 .49	11130 13375	 14620
5358	4	8/12	Marshall.......	2	17.54 Dry	37.42 45.37	40.11 48.63	4.93 6.00	2.19 2.56	.42 .50	11273 13669	 14703
5412	11	8/12	Marshall.......	2	12.92 Dry	41.69 47.87	37.60 43.19	7.78 8.94	2.38 2.73	.64 .73	11597 13319	 14836
5413	11	8/12	Marshall.......	2	13.10 Dry	38.73 44.56	39.64 45.61	8.53 9.83	3.47 3.99	.65 .75	11414 13134	 14832
5414	11	8/12	Marshall.......	2	13.82 Dry	41.34 47.97	35.88 41.64	8.96 10.39	3.28 3.81	.50 .59	11296 13106	 14901
5232	22	7/12	McDonough....	2	19.35 Dry	31.70 39.35	40.61 50.40	8.34 10.35	2.31 2.87	.37 .46	10392 12898	 14605
5233	22	7/12	McDonough....	2	16.46 Dry	33.94 40.63	42.46 50.83	7.14 8.54	1.71 2.04	.11 .14	11064 13246	 14660
5234	22	7/12	McDonough....	2	16.39 Dry	34.26 40.97	41.36 49.47	7.99 9.56	2.04 2.44	.33 .40	10977 13130	 14725
9728	213	11/16	McDonough....	2	14.89 Dry	35.48 41.68	40.75 47.88	8.88 10.44	3.78 4.43	....	10969 12887	 14678
9729	213	11/16	McDonough....	2	16.83 Dry	34.68 41.71	39.79 47.83	8.70 10.46	3.94 4.74	....	10628 12778	 14565
5426	100	8/12	McLean.........	2	10.13 Dry	45.00 50.07	35.92 39.97	8.95 9.96	3.27 3.59	.74 .82	11710 13029	 14723
5427	100	8/12	McLean.........	2	11.34 Dry	40.05 45.17	39.18 44.19	9.43 10.64	3.18 3.58	.90 1.01	11394 12851	 14643
5428	100	8/12	McLean.........	2	10.61 Dry	41.87 46.84	35.94 40.21	11.58 12.95	3.79 4.24	.92 1.03	11225 12557	 14752
5429	100	8/12	McLean.........	2	12.31 Dry	42.17 48.09	38.03 43.37	7.49 8.54	2.69 3.07	.94 1.07	11636 13270	 14722
5430	100	8/12	McLean.........	2	12.00 Dry	42.00 47.73	37.96 43.14	8.04 9.13	2.37 2.70	1.23 1.40	11634 13220	 14759

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[1] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 85, 1913.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5433	100	8/12	McLean..........	2	11.27	42.17	39.27	7.29	2.91	1.12	11784	......
					Dry	47.53	44.25	8.22	3.28	1.26	13279	14684
3044	[2]B. M. 55	3/'06	McLean..........	2	10.25	35.88	40.11	13.76	2.80	......	11149	......
					Dry	39.98	44.69	15.33	3.12	......	12422	15028
3045	[2]B. M. 55	3/'06	McLean..........	2	9.88	35.99	38.22	15.91	3.15	......	......	......
					Dry	39.93	42.42	17.65	3.50	......	......	......
9709	214	11/16	Schuyler..........	2	12.34	38.11	42.29	7.26	4.32	......	11841	......
					Dry	43.48	48.24	8.28	4.92	......	13507	15011
9708	214	11/16	Schuyler..........	2	12.73	37.56	41.88	7.83	4.77	......	11621	......
					Dry	43.04	47.99	8.97	5.46	......	13316	14924
No. 5 Coal.												
5283	31	8/12	Fulton..........	5	15.18	37.17	35.17	12.48	3.45	1.70	10201	......
					Dry	43.82	41.45	14.73	4.07	2.00	12026	14441
5284	31	8/12	Fulton..........	5	16.94	35.68	37.15	10.23	2.98	1.31	10314	......
					Dry	42.95	44.73	12.32	3.59	1.57	12418	14446
5285	31	8/12	Fulton..........	5	18.42	34.98	37.66	8.94	2.33	.86	10270	......
					Dry	42.88	46.15	10.97	2.85	1.06	12587	14371
5296	31	8/12	Fulton..........	5	16.82	37.28	33.45	12.45	2.84	1.69	10580	......
					Dry	44.81	40.23	14.96	3.42	2.02	12038	14479
5298	31	8/12	Fulton..........	5	16.52	37.17	36.54	9.77	3.91	.81	10394	......
					Dry	44.52	43.78	11.70	4.69	.97	12451	14409
5341	31	8/12	Fulton..........	5	17.37	35.71	37.86	9.06	2.34	1.14	10420	......
					Dry	43.22	45.82	10.96	2.83	1.38	12610	14398
5293	29	8/12	Fulton..........	5	17.13	36.23	34.44	12.20	3.03	1.79	9846	......
					Dry	43.72	41.55	14.73	3.66	2.16	11882	14252
5297	29	8/12	Fulton..........	5	16.59	35.98	37.20	10.23	4.07	1.77	10271	......
					Dry	43.14	44.61	12.25	4.88	2.12	12314	14354
5300	29	8/12	Fulton..........	5	15.41	35.67	39.04	9.88	3.31	.52	10579	......
					Dry	42.16	46.15	11.69	3.92	.61	12505	14443
5292	28	8/12	Fulton..........	5	17.39	37.00	35.69	9.92	2.74	1.14	10273	......
					Dry	44.79	43.20	12.01	3.28	1.36	12435	14416
5295	28	8/12	Fulton..........	5	16.33	36.27	36.58	10.82	3.40	1.94	10246	......
					Dry	43.34	43.72	12.94	4.06	2.32	12247	14371
5299	28	8/12	Fulton..........	5	16.33	36.75	38.02	8.90	2.59	1.02	10604	......
					Dry	43.92	45.44	10.64	3.10	1.22	12674	14421
5342	32	8/12	Fulton..........	5	13.66	38.46	37.06	10.82	3.64	1.26	10689	......
					Dry	44.54	42.92	12.54	4.22	1.46	12379	14462
5343	32	8/12	Fulton..........	5	14.53	37.46	38.35	9.66	3.18	1.60	10804	......
					Dry	43.83	44.87	11.30	3.72	1.87	12641	14525
5344	32	8/12	Fulton..........	5	15.80	35.84	37.67	10.69	3.00	1.79	10460	......
					Dry	42.56	44.74	12.70	3.57	2.12	12423	14520
5345	30	8/12	Fulton..........	5	16.36	33.91	38.19	11.54	2.93	1.27	10186	......
					Dry	40.54	45.66	13.80	3.50	1.51	12179	14431
5346	30	8/12	Fulton..........	5	16.33	35.50	37.01	11.16	2.89	1.84	10220	......
					Dry	42.42	44.23	13.35	3.45	2.20	12213	14389

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[2] Ibid.

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	Conuty	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free: Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
5347	30	8/12	Fulton..........	5	15.85	36.12	38.12	9.91	3.36	1.47	10494	......
					Dry	42.92	45.30	11.78	4.00	1.75	12471	14386
12442	110	3/21	Fulton..........	5	15.43	33.62	39.47	11.48	2.50	1.41	10389	......
					Dry	39.76	46.67	13.57	2.66	1.67	12285	14473
12443	111	3/21	Fulton..........	5	14.43	34.60	39.09	11.88	2.82	2.45	10320	......
					Dry	40.43	45.69	13.88	3.29	2.86	12061	14297
12444	111	3/21	Fulton..........	5	15.00	33.10	37.31	14.59	3.38	2.86	9834	....
					Dry	38.94	43.89	17.17	3.98	3.36	11569	14300
12445	111	3/21	Fulton..........	5	14.69	34.07	40.18	11.06	2.83	1.75	10383	......
					Dry	39.94	47.09	12.97	3.32	2.05	12172	14266
12446	111	3/21	Fulton..........	5	14.52	34.46	37.64	13.38	2.91	2.74	10045	.....
					Dry	40.31	44.04	15.65	3.40	3.21	11752	14261
12447	111	3/21	Fulton..........	5	14.75	33.18	38.89	13.18	3.70	1.54	9869	.....
					Dry	38.92	45.62	15.46	4.34	1.81	11577	14298
12448	111	3/21	Fulton..........	5	14.28	33.93	38.76	12.03	2.56	1.98	10329	...
					Dry	40.75	45.22	14.03	2.99	2.31	12061	14316
12472	112	3/21	Fulton..........	5	15.32	35.12	38.05	11.51	2.59	1.41	10482	......
					Dry	41.48	44.93	13.59	3.06	1.66	12379	14617
12473	112	3/21	Fulton..........	5	15.09	35.37	39.41	10.13	2.68	1.79	10741	.....
					Dry	41.66	46.41	11.93	3.16	1.66	12650	14631
12474	112	3/21	Fulton..........	5	15.56	35.68	38.92	9.84	2.43	1.33	10753	..
					Dry	42.26	46.09	11.65	2.88	1.58	12735	14668
12475	112	3/21	Fulton..........	5	14.56	35.37	38.98	11.09	2.72	1.38	10581	......
					Dry	41.40	45.62	12.98	3.19	1.62	12384	14512
12476	112	3/21	Fulton..........	5	15.39	33.82	38.77	12.02	3.40	1.67	10338	......
					Dry	39.97	45.82	14.21	4.02	1.97	12219	14565
12477	112	3/21	Fulton..........	5	15.66	34.65	37.56	12.13	2.93	1.98	10242	..
					Dry	41.08	44.59	14.38	3.47	2.23	12144	14583
12439	113	3/21	Fulton..........	5	13.37	36.03	39.03	11.57	3.06	1.46	10787	...
					Dry	41.59	45.06	13.35	3.52	1.69	12452	14670
12440	113	3/21	Fulton..........	5	14.44	34.71	38.58	12.27	2.17	1.80	10578	....
					Dry	40.57	45.09	14.34	2.54	2.10	12364	14683
12441	113	3/21	Fulton..........	5	14.96	33.65	39.96	11.43	4.32	1.11	10502	......
					Dry	39.57	46.99	13.44	5.08	1.30	12350	14616
12459	114	3/21	Fulton..........	5	14.57	35.24	39.58	10.61	2.89	1.00	10562	..
					Dry	41.25	46.33	12.42	3.38	1.17	12363	14391
12460	114	3/21	Fulton..........	5	16.16	35.65	37.89	10.30	2.50	1.56	10422	..
					Dry	42.52	45.19	12.29	2.98	1.86	12431	14434
12461	114	3/21	Fulton..........	5	13.35	37.84	39.86	8.95	2.22	1.77	10843	
					Dry	43.67	46.00	10.33	2.56	2.04	12514	14150
12462	114	3/21	Fulton..........	5	15.86	35.20	37.32	11.62	3.49	1.31	10198	...
					Dry	41.84	44.35	13.81	4.15	1.56	12120	14380
12463	114	3/21	Fulton..........	5	14.34	35.09	36.72	13.85	3.84	2.47	9944	
					Dry	40.96	42.87	16.17	4.48	2.86	11609	14217
12464	114	3/21	Fulton..........	5	14.62	36.18	39.21	9.99	2.43	1.49	10719	
					Dry	42.38	45.92	11.70	2.85	1.74	12555	14465

TABLE 2—*Analyses of some samples not exactly indicative of commercial output*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analyses of coal 1st. "As received," with total moisture 2nd. "Dry" or moisture free: Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	3.6	1.57	10270	------
					Dry	[illegible]	[illegible]	14.7	4.3	1.86	12180	14511
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	9.1	2.6	.75	10950	------
					Dry	[illegible]	[illegible]	[illegible]	3.1	.88	12860	14649
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	4.38	.92	10330	------
					Dry	[illegible]	[illegible]	[illegible]	5.21	1.10	12280	14569
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	3.82	.61	10464	------
					Dry	[illegible]	[illegible]	[illegible]	4.58	.74	12559	14579
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	3.45	1.00	10608	------
					Dry	[illegible]	[illegible]	[illegible]	4.04	1.17	12411	14679
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	3.5	------	10410	------
					Dry	[illegible]	[illegible]	[illegible]	4.1	------	12040	14580
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	4.1	.92	11070	------
					Dry	[illegible]	[illegible]	[illegible]	4.6	1.04	12510	14758
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	3.3	.83	10950	------
					Dry	[illegible]	[illegible]	[illegible]	3.8	.97	12670	14673
[illegible]	[illegible]	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	4.0	1.34	10690	------
					Dry	[illegible]	[illegible]	14.7	4.7	1.54	12310	14808
[illegible]	1	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	3.01	------	------	------
					Dry	[illegible]	[illegible]	[illegible]	3.55	------	------	------
[illegible]	1	[illegible]	Fulton	3	[illegible]	[illegible]	[illegible]	[illegible]	2.99	------	10620	------
					Dry	[illegible]	[illegible]	[illegible]	3.55	------	12593	14519
[illegible]	47	[illegible]	Gallatin	3	[illegible]	[illegible]	[illegible]	[illegible]	3.95	1.38	11883	------
					Dry	[illegible]	[illegible]	[illegible]	4.22	1.45	12558	14900
[illegible]	47	[illegible]	Gallatin	3	[illegible]	[illegible]	[illegible]	[illegible]	3.12	.78	12338	------
					Dry	[illegible]	[illegible]	21.02	3.31	.83	13066	14953
[illegible]	47	[illegible]	Gallatin	3	[illegible]	[illegible]	[illegible]	12.02	3.30	.87	11938	------
					Dry	[illegible]	[illegible]	12.82	3.52	.93	12728	14903
[illegible]	....	[illegible]	Gallatin	3	[illegible]	[illegible]	[illegible]	8.76	2.85	.01	12997	------
					Dry	[illegible]	[illegible]	9.16	2.97	.01	13566	15164
[illegible]	....	[illegible]	Gallatin	3	[illegible]	[illegible]	[illegible]	8.98	3.61	.03	12975	------
					Dry	[illegible]	[illegible]	9.36	3.76	.03	13536	15186
[illegible]	....	[illegible]	Gallatin	3	[illegible]	[illegible]	[illegible]	10.32	4.55	.04	12818	------
					Dry	[illegible]	[illegible]	10.72	4.73	.04	13307	15078
[illegible]	....	[illegible]	Gallatin	5	[illegible]	[illegible]	[illegible]	11.98	3.53	.03	12449	------
					Dry	[illegible]	[illegible]	12.48	3.67	.03	12958	15117
[illegible]	....	[illegible]	Gallatin	4	[illegible]	[illegible]	[illegible]	5.19	.84	.03	13035	------
					Dry	[illegible]	[illegible]	5.59	.90	.03	14036	14970
[illegible]	....	[illegible]	Gallatin		4.73	[illegible]	48.65	11.71	4.78	.04	12429	------
					Dry	[illegible]	52.12	12.29	5.02	.04	13045	15240
[illegible]	....	[illegible] 12	Gallatin		[illegible]	33.71	51.84	10.41	4.19	.02	12783	------
					Dry	[illegible]	54.01	10.86	4.37	.02	13319	15356
[illegible]	135	7 21	Gallatin	5	4.27	34.39	49.23	12.01	3.85	.35	12270	------
					Dry	35.96	51.48	12.56	4.03	.37	12631	14995

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[3] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 85, 1913.
[4] This and the two following samples are from the "Ice House" coal of Kentucky reports.

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free: Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
12941	135	7/21	Gallatin........	5	4.04	35.68	50.92	9.36	3.23	.24	12828	......
					Dry	37.18	53.06	9.76	3.37	.24	13200	15066
12942	135	7/21	Gallatin........	5	3.49	36.09	50.54	9.88	3.04	.18	12707	......
					Dry	37.39	52.37	10.24	3.15	.18	13162	14912
13425	¹B. M. 4	11/15	Gallatin........	5	3.93	36.82	51.04	8.21	2.80	......	13106	......
					Dry	38.33	53.12	8.55	2.91	......	13642	15134
5391	....	8/12	LaSalle........	5	15.52	41.56	32.57	10.35	4.08	.27	10425	......
					Dry	49.18	38.55	12.27	4.83	.34	12400	14384
5392	....	8/12	LaSalle........	5	14.13	39.42	35.96	10.49	3.22	.96	10636	......
					Dry	45.90	41.89	12.21	3.75	1.12	12387	14393
5393	....	8/12	LaSalle	5	14.64	43.01	34.25	8.10	2.83	.56	10961	......
					Dry	50.38	40.12	9.50	3.32	.66	12841	14415
10519	215	8/18	Livingston.....	5	10.22	36.56	42.14	11.08	3.09	......	11630	......
					Dry	40.72	46.94	12.34	3.44	......	12955	15077
10523	215	8/18	Livingston.....	5	10.05	32.49	37.59	19.87	7.61	......	10125	......
					Dry	38.12	41.80	22.08	8.46	......	11256	15151
10524	215	8/18	Livingston.....	5	7.95	38.03	43.55	10.47	3.52	......	12020	......
					Dry	41.31	47.31	11.38	3.82	......	13057	15026
10530	216	8/18	Livingston.....	5	13.23	36.90	39.16	11.42	1.46	......	10924	......
					Dry	41.71	45.13	13.16	1.69	......	12510	14738
10521	216	8/18	Livingston	5	14.03	36.36	39.69	9.92	2.74	......	11124	......
					Dry	42.29	46.17	11.54	3.18	......	12939	14899
10522	216	8/18	Livingston.....	5	14.04	34.76	38.03	13.17	5.25	......	10502	......
					Dry	40.44	44.24	15.32	6.11	......	12216	14871
5263	33	8/12	Logan..........	5	14.64	37.87	35.56	11.93	3.60	1.10	10400	......
					Dry	44.36	41.66	13.98	4.22	1.28	12183	14497
5264	33	8/12	Logan..........	5	13.98	36.86	37.98	11.18	3.14	1.43	10549	......
					Dry	42.84	44.16	13.00	3.65	1.67	12264	14391
5265	33	8/12	Logan..........	5	13.99	36.85	38.17	10.99	3.26	1.32	10519	......
					Dry	42.85	44.37	12.78	3.79	1.53	12230	14313
81501	109	9/21	Logan..........	5	14.36	35.36	39.95	10.33	2.73	1.20	10780	......
					Dry	41.29	46.65	12.06	3.19	1.40	12599	14595
81502	109	9/21	Logan..........	5	13.70	35.46	40.38	10.46	3.38	1.11	10813	......
					Dry	41.09	46.79	12.12	3.92	1.29	12530	14553
81503	109	9/21	Logan..........	5	12.55	35.93	42.13	9.39	2.76	.84	11169	......
					Dry	41.09	48.17	10.74	3.16	.96	12772	14643
2881	²B. M. 37	2/06	Logan..........	5	14.77	32.90	39.75	12.58	3.95	......	10406	......
					Dry	38.60	46.64	14.76	4.63	......	12209	14687
2882	²B. M. 37	2/06	Logan..........	5	15.52	32.27	39.86	12.35	3.65	......	......	......
					Dry	38.20	47.18	14.62	4.32	......	......	......
3003	²B. M. 37	2/06	Logan..........	5	15.68	32.41	39.82	12.09	3.51	......	10337	......
					Dry	38.44	47.22	14.34	4.16	......	12260	14656
5200	42	7/12	Macon....	5	13.52	36.72	39.66	10.10	4.23	.09	10646	......
					Dry	42.46	45.86	11.68	4.95	.11	12311	14405

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[1] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 34, 1918.

[2] Lord, N. W., and others, Analyses of coals. U. S. Bureau of Mines Bull. 22, pt. 1, p. 85, 1913.

Table 2.—Analyses of mine samples not exactly indicative of commercial output.—Continued.

Laboratory number	Mine number	Date	County	Coal bed	Proximate analysis of coal: 1st, as received, with moisture; 2nd, "Dry" or moisture free Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO2	B. t. u.	Unit coal
[illegible]291	42	[illegible]	Macoupin	5	[illegible] Dry	37.72 43.[illegible]	40.24 46.70	8.32 9.[illegible]	3.[illegible] [illegible]	.[illegible] .[illegible]	[illegible] 12796	...... 14[illegible]
[illegible]	42	[illegible]	Macoupin	5	14.36 Dry	36.[illegible] 4[illegible]	39.35 45.37	[illegible] 10.75	3.[illegible] 4.40	.[illegible] .22	[illegible] 12[illegible]	 14447
[illegible]14	41	[illegible]	Macoupin	5	14.76 Dry	35.[illegible] 41.[illegible]	[illegible] 44.[illegible]	11.70 13.73	3.24 3.91	.40 1.[illegible]	[illegible] 12[illegible]	 14443
[illegible]	41	[illegible]	Macoupin	5	14.54 Dry	36.33 42.51	38.11 44.47	11.72 13.[illegible]	3.47 4.[illegible]	.68 .7[illegible]	10445 12244	 14265
[illegible]46	41	[illegible]	Macoupin	[illegible]	14.14 Dry	36.21 42.[illegible]8	38.07 44.34	11.58 13.48	3.24 3.77	1.12 1.31	104[illegible] 12[illegible]	 14433
81[illegible]	[illegible]	[illegible]	Macoupin	5	[illegible] Dry	34.[illegible] 39.[illegible]	42.36 49.40	8.40 10.24	2.73 3.14	.27 .34	10624 12582	 14247
81[illegible]	[illegible]	[illegible]	Macoupin	5	[illegible].67 Dry	35.73 40.[illegible]4	43.18 49.32	8.50 9.73	3.32 3.90	.03 .03	11[illegible] 12714	 14321
81[illegible]	[illegible]	[illegible]	Macoupin	5	[illegible].71 Dry	35.46 41.22	42.79 49.02	8.52 9.76	3.66 4.19	.17 .19	11063 12706	 14328
5100	14	[illegible]	Menard	5	16.29 Dry	36.[illegible] 43.40	38.73 46.26	8.32 9.[illegible]4	3.65 4.36	.59 .71	10747 12838	 14528
5101	14	[illegible]	Menard	[illegible]	15.44 Dry	36.38 43.[illegible]	39.72 46.[illegible]	9.47 10.[illegible]1	3.34 3.95	.26 .31	10841 12820	 14505
5102	14	[illegible]	Menard	5	20.27 Dry	34.58 43.37	37.43 46.44	7.72 9.69	3.31 4.16	.63 .79	9919 12441	 14402
5431	100	[illegible]	McLean	5	[illegible].58 Dry	38.34 44.58	35.90 41.09	12.48 14.33	3.60 4.14	1.17 1.35	10601 12168	 14544
5432	100	[illegible]	McLean	5	[illegible].14 Dry	38.19 44.30	36.72 42.57	11.55 13.33	3.59 4.14	1.31 1.51	10743 12397	 14625
5434	100	[illegible]	McLean	5	[illegible].73 Dry	36.70 42.[illegible]	36.[illegible]4 41.[illegible]	13.34 15.47	3.99 4.62	1.19 1.30	10399 12054	 14639
[illegible]	25	[illegible]	Peoria	[illegible]	[illegible].22 Dry	36.65 42.73	37.04 43.19	12.08 14.08	3.39 3.96	1.55 1.81	10483 12220	 14553
[illegible]290	25	[illegible]	Peoria	5	14.54 Dry	37.41 43.[illegible]	37.32 43.67	10.73 12.56	3.27 3.82	1.18 1.38	10706 12536	 14625
5291	25	[illegible]	Peoria	5	[illegible].80 Dry	36.36 43.41	37.28 44.38	10.26 12.21	3.65 4.35	.90 1.07	10683 12598	 14664
5303	26	[illegible]	Peoria	5	[illegible].80 Dry	36.36 42.43	37.54 44.99	10.40 12.38	2.90 3.46	1.27 1.51	10515 12519	 14673
5304	26	[illegible]	Peoria	5	14.23 Dry	37.47 43.[illegible]2	37.36 43.56	11.00 12.82	3.14 3.66	2.17 2.53	10573 12327	 14433
5305	26	[illegible]	Peoria	5	14.78 Dry	35.45 42.15	35.34 41.46	13.95 16.36	3.19 3.74	2.00 2.34	10173 11935	 14636
94560	106	1-22	Peoria	5	[illegible].5 Dry	30.[illegible] 35.3	45.5 52.4	10.3 11.9	3.2 3.7	.96 1.0	10900 12800	 14586
94561	106	1-22	Peoria	5	13.1 Dry	29.7 35.[illegible]	45.8 53.4	9.4 11.1	3.6 4.3	.43 .50	10870 12800	 14083
94562	106	1-22	Peoria	3	11.4 Dry	30.5 34.5	43.1 48.9	14.7 16.6	4.6 5.2	1.96 2.11	10640 11930	 14733

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—**Continued.**

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
84250	107	3 22	Peoria........	5	13.0 Dry	35.4 40.6	40.9 47.1	10.7 12.3	3.0 3.4	1.91 2.19	10830 12450	 14474
84251	107	3 22	Peoria	5	14.9 Dry	33.5 39.3	39.1 46.0	12.5 14.7	3.0 3.5	2.17 2.55	10450 12280	 14728
84252	107	3 22	Peoria...... . .	5	14.4 Dry	34.8 40.6	39.9 46.7	10.9 12.7	2.9 3.3	1.23 1.43	10740 12540	.. . 14651
21032	[7]B. M. 2	2 15	Peoria	5	15.66 Dry	34.74 41.19	40.38 47.88	9.22 10.93	2.64 3.13	....	10798 12803	. 14804
21033	[7]B. M. 2	2 15	Peoria......	5	15.38 Dry	34.51 40.78	39.48 46.66	10.63 12.56	2.75 3.25	.. ..	10645 12580	... 14671
21034	[7]B. M. 2	2 15	Peoria...... .	5	15.34 Dry	34.25 40.46	40.80 48.19	9.61 11.35	3.11 3.67	....	10741 12686	... 14584
21035	[7]B. M. 2	2 15	Peoria	5	15.44 Dry	34.72 41.06	39.81 47.08	10.03 11.86	2.85 3.37	. ... ..	10744 12706	. 14691
22082	[7]B. M. 3	10 15	Peoria.... ...	5	15.03 Dry	34.56 40.67	39.05 45.96	11.36 13.37	2.64 3.11	. .. .	10490 12346	. . 14538
22083	[7]B. M. 3	10 15	Peoria.........	5	15.41 Dry	33.87 40.04	38.85 45.93	11.87 14.03	2.88 3.40	.. .	10386 12278	.. 14593
22084	[7]B. M. 3	10 15	Peoria.... ..	5	15.51 Dry	34.77 41.15	38.69 45.79	11.03 13.06	2.62 3.10	.	10489 12415	.. 14562
22085	[7]B. M. 3	10 15	Peoria.	5	15.57 Dry	34.08 40.36	38.18 45.23	12.17 14.41	3.42 4.05	.	10283 12179	. 14566
22086	[7]B. M. 3	10 15	Peoria.......	5	15.41 Dry	34.34 40.60	38.52 45.53	11.73 13.87	2.97 3.51	.	10422 12321	14618
4985	43	6 12	Saline.	5	6.34 Dry	37.72 40.27	48.20 51.46	7.74 8.27	2.03 2.16	.61 .65	12620 13474	14869
4986	43	6 12	Saline	5	6.40 Dry	37.11 39.65	49.59 52.97	6.90 7.38	2.27 2.43	.40 .43	12678 13546	. 14800
4987	43	6 12	Saline	5	8.85 Dry	32.53 35.65	51.52 56.57	7.10 7.78	.92 1.00	.66 .72	12321 13502	14774
4989	43	6 12	Saline.........	5	6.80 Dry	35.06 37.61	50.39 54.07	7.75 8.32	2.30 2.46	.03 .03	12514 13428	14853
4990	43	6 12	Saline . .	5	6.02 Dry	38.23 40.68	47.53 50.58	8.22 8.74	2.67 2.84	.45 .48	12538 13341	14831
4992	43	6 12	Saline.	5	7.39 Dry	35.38 38.20	50.73 54.78	6.50 7.02	2.15 2.32	.01 .01	12642 13650	14848
4991	44	6 12	Saline.. .. .	5	6.49 Dry	35.85 38.34	50.46 53.97	7.20 7.69	2.82 3.02	.01 .01	12614 13511	14841
4993	44	6 12	Saline........	5	6.71 Dry	35.68 38.24	49.64 53.21	7.97 8.55	2.69 2.88	.00 .00	12482 13379	14839
4994	44	6 12	Saline........	5	6.90 Dry	34.42 36.97	48.55 52.16	10.13 10.87	2.16 2.32	.01 .03	12088 12984	14793

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[7] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 35, 1918.

TABLE 1.—*Analyses of mine samples not exactly indicative of commercial output*—Continued.

[illegible]	[illegible]	[illegible]	County	[illegible]	Proximate analyses of coal "As received," with total moisture, and "Dry" or moisture free Moisture	 Volatile matter	 Fixed carbon	 Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	7.72 8.27	2.39 2.55	.14 .16	12092 13332	 14725
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	8.40 [illegible]	2.78 3.01	.01 .01	12336 13329	 14201
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	40.43 [illegible]	7.37 8.14	2.30 2.46	.16 .18	12485 13415	 14792
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	46.30 52.25	[illegible] 10.77	2.42 2.42	1.75 1.99	11956 12984	 14652
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	7.37 8.18	2.63 2.94	.31 .35	12408 13308	 14794
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	51.39 55.16	7.18 7.90	2.61 2.84	.05 .06	12346 13419	 14732
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	45.42 [illegible]	10.52 11.10	4.16 4.38	.46 .49	12280 12932	 14847
[illegible]	[illegible]	[illegible]	Saline	[illegible]	[illegible] Dry	[illegible] [illegible]	45.90 [illegible]	11.70 12.58	4.17 5.26	.72 .76	11962 12862	 14909
[illegible]	[illegible]	[illegible]	Saline	5	[illegible] Dry	[illegible] [illegible]	45.40 48.35	10.27 10.90	4.77 5.01	.47 .49	12355 12981	 14815
[illegible]	[illegible]	[illegible]	Saline	5	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	8.61 [illegible]	2.40 2.53	.38 .41	12192 13263	 14818
5020	[illegible]	[illegible]	Saline	5	[illegible] Dry	[illegible] [illegible]	48.60 [illegible]	8.16 8.84	2.52 2.74	.32 .36	12304 13331	 14833
5021	[illegible]	[illegible]	Saline	5	4.25 Dry	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	2.40 2.61	.35 .42	11964 13040	 14684
5022	[illegible]	[illegible]	Saline	5	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	8.17 8.72	3.31 3.58	.23 .25	12060 13057	 14716
5023	[illegible]	[illegible]	Saline	5	[illegible] Dry	[illegible] [illegible]	48.70 [illegible]	[illegible] [illegible]	2.42 2.54	.74 .80	12380 13051	 14717
5024	44	[illegible]	Saline	5	7.65 Dry	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	3.48 3.79	.24 .26	11571 12540	 14675
12931	124	7 21	Saline	5	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	8.14 8.77	2.58 2.79	.13 .14	12354 13313	 14796
12932	124	7 21	Saline	5	6.78 Dry	[illegible] [illegible]	[illegible] [illegible]	7.64 [illegible]	2.40 2.58	.11 .11	12490 13395	 14798
12933	124	7 21	Saline	5	6.62 Dry	[illegible] [illegible]	52.57 [illegible]	8.22 8.81	1.74 1.96	.42 .45	12463 13347	 14832
12934	125	7 21	Saline	5	6.57 Dry	[illegible] [illegible]	52.48 56.22	7.35 7.87	1.73 2.17	.13 .13	12609 13507	 14834
12935	125	7 21	Saline	5	6.28 Dry	[illegible] [illegible]	[illegible] 54.83	8.89 9.41	3.27 3.28	.09 .09	12357 13155	 14806
12936	125	7 21	Saline	5	4.45 Dry	[illegible] [illegible]	52.28 [illegible]	7.22 7.75	2.11 2.27	.05 .05	12612 13535	 14854
12937	126	7 21	Saline	5	[illegible] Dry	[illegible] [illegible]	[illegible] 56.45	7.14 7.57	2.29 2.43	.04 .04	12634 13394	 14866
12938	126	7 21	Saline	5	6.13 Dry	34.28 36.52	51.83 55.22	7.76 8.26	2.75 2.60	.27 .29	12615 13439	 14830

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
12839	126	7 21	Saline..........	5	6.18	33.97	51.99	7.86	2.65	.16	12508	......
					Dry	36.21	55.42	8.37	2.82	.17	13191	14753
12901	127	7/21	Saline..........	5	5.51	33.34	53.39	7.76	1.92	.34	12687	......
					Dry	35.28	56.51	8.21	2.03	.36	13427	14771
12902	127	7 21	Saline..........	5	6.05	34.38	51.87	7.70	1.98	.42	12580	......
					Dry	36.59	55.21	8.20	2.11	.44	13390	14765
12903	127	7 21	Saline..........	5	5.50	33.64	52.49	8.37	2.51	.51	12576	......
					Dry	35.60	55.54	8.86	2.66	.54	13308	14806
12911	128	7 21	Saline..........	5	6.52	33.57	52.37	7.54	2.57	.03	12552	......
					Dry	35.91	56.02	8.07	2.75	.03	13428	14805
12912	128	7/21	Saline..........	5	6.84	30.30	48.02	14.84	1.46	.03	11343	......
					Dry	32.52	51.55	15.93	1.57	.03	12176	14764
12913	128	7 21	Saline..........	5	6.17	32.87	53.54	7.42	1.60	.18	12631	......
					Dry	35.03	57.06	7.91	1.71	.14	13462	14777
12917	129	7 21	Saline..........	5	5.62	34.61	52.52	7.25	2.02	.08	12781	......
					Dry	36.67	55.65	7.68	2.14	.09	13542	14840
12918	129	7 21	Saline..........	5	5.75	35.01	52.65	6.59	2.05	.05	12800	......
					Dry	37.15	55.86	6.99	2.18	.06	13581	14927
12919	129	7/21	Saline..........	5	6.58	32.89	53.29	7.24	2.06	.14	12565	......
					Dry	35.21	57.14	7.75	2.20	.15	13450	14754
12914	130	7 21	Saline..........	5	6.05	33.67	51.48	8.80	2.72	.34	12401	......
					Dry	35.84	54.79	9.37	2.90	.35	13200	14786
12915	130	7/21	Saline..........	5	6.69	32.54	51.44	9.33	2.62	.06	12225	......
					Dry	34.88	55.13	9.99	2.81	.07	13101	14785
12916	130	7 21	Saline..........	5	5.93	33.79	51.51	8.77	2.63	.10	12393	......
					Dry	35.92	54.76	9.32	2.80	.11	13774	14746
5494	131	8 12	Saline..........	5	3.72	34.44	52.91	8.93	3.76	.03	13032	......
					Dry	35.77	54.96	9.27	3.90	.03	13535	15186
5530	132	8 12	Saline..........	5	4.03	33.71	51.84	10.42	4.19	.02	12783	......
					Dry	35.13	54.01	10.86	4.37	.02	13319	15255
5529	133	8 12	Saline..........	5	3.40	33.33	55.18	8.09	4.25	.03	13401	......
					Dry	34.50	57.12	8.38	4.40	.03	13872	15420
4413	*B. M.	1/07	Saline..........	5	7.55	33.85	51.45	7.15	1.56	.....	.....	.....
	5				Dry	36.61	55.66	7.73	1.69	.....	.....	.....
4414	*B. M.	1/07	Saline..........	5	7.51	32.81	52.20	7.48	1.58	.....	12686	......
	5				Dry	35.47	56.44	8.09	1.71	.....	13716	15000
7420	*B. M.	1/07	Saline..........	5	6.98	31.64	53.41	7.97	.....	.....	.....	.....
	5				Dry	34.01	57.42	8.57	.....	.....	.....	.....
7421	*B. M.	1/07	Saline..........	5	7.40	31.28	54.74	6.58	.....	.....	.....	.....
	5				Dry	33.78	59.11	7.11	.....	.....	.....	.....
4622	*B. M.	1/07	Saline..........	5	7.81	33.54	50.27	8.38	2.36	.....	12418	
	5				Dry	36.38	54.53	9.09	2.56	.....	13469	15552
4636	*B. M.	1/07	Saline..........	5	9.33	30.92	47.86	11.89	2.76	.....	11572	......
	5				Dry	34.10	52.79	13.11	3.04	.....	12764	14984

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* Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 90, 1913.

TABLE [illegible]—[illegible] indicative of commercial [illegible]—Continued.

[illegible]

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[1] Fieldner, A. C., [illegible] Analyses of [illegible] U. S. Bureau of Mines Bull. 85, p. 27, 1914.

[illegible]

[2] Lord, N. W., and others, Analyses of coals, U. S. Bureau of Mines Bull. 22, pt. 1, p. 91, 1913.

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free — Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5198	38	7/12	Sangamon......	5	14.44	38.22	37.68	9.66	3.79	.63	10746	......
					Dry	44.67	44.04	11.29	4.43	.73	12549	14435
5199	38	7/12	Sangamon......	5	14.08	38.05	35.30	12.57	5.87	.60	10228	......
					Dry	44.28	41.09	14.63	6.83	.69	11903	14366
81448	119	9/21	Sangamon......	5	13.79	34.86	39.58	11.77	3.88	.58	10576	......
					Dry	40.44	45.91	13.65	4.50	.67	12268	14546
81449	119	9/21	Sangamon......	5	14.78	35.20	39.74	10.28	3.72	.33	10606	......
					Dry	41.30	46.64	12.06	4.37	.39	12445	14454
81450	119	9/21	Sangamon......	5	13.62	37.50	39.30	9.58	3.62	.39	10876	......
					Dry	43.41	45.50	11.09	4.06	.45	12591	14439
81452	120	9/21	Sangamon......	5	13.19	36.95	41.18	8.68	3.65	.44	11120	......
					Dry	42.56	47.44	10.00	4.20	.51	12810	14381
81453	120	9/21	Sangamon......	5	13.75	37.20	37.60	11.45	4.38	1.09	10567	......
					Dry	43.13	43.59	13.28	5.08	1.26	12252	14478
81454	120	9/21	Sangamon......	5	13.84	36.29	38.94	10.83	3.76	.85	10672	......
					Dry	42.17	45.25	12.58	4.37	.99	12401	14499
81456	121	9/21	Sangamon......	5	13.26	34.27	41.93	10.54	3.71	.16	10824	......
					Dry	39.51	48.34	12.15	4.28	.18	12479	14509
81457	121	9/21	Sangamon......	5	14.14	35.08	40.61	10.17	3.87	.67	10709	......
					Dry	40.86	47.30	11.84	4.51	.78	12473	14453
81458	121	9/21	Sangamon......	5	14.79	34.30	40.77	10.14	3.68	.53	10691	......
					Dry	40.25	47.85	11.90	4.32	.62	12547	14544
81440	122	9/21	Sangamon......	5	13.09	36.51	41.14	9.26	3.77	.70	10935	......
					Dry	42.01	47.34	10.65	4.34	.81	12582	14609
81441	122	9/21	Sangamon......	5	12.76	35.36	41.92	9.96	3.98	.82	10907	......
					Dry	40.53	48.05	11.42	4.56	.94	12502	14411
81442	122	9/21	Sangamon......	5	13.62	35.00	40.80	10.58	3.95	.35	10594	......
					Dry	40.52	47.23	12.25	4.57	.41	12264	14282
81311	217	9/21	Shelby.........	5	12.10	35.78	40.71	11.41	3.46	.78	10807	......
					Dry	40.71	46.31	12.98	3.94	.89	12295	14506
81312	217	9/21	Shelby.........	5	10.42	36.85	42.83	9.90	3.48	.23	11335	......
					Dry	41.14	47.81	11.05	3.88	.26	12653	14499
81313	217	9/21	Shelby.........	5	10.71	37.16	40.91	11.22	4.16	.57	11009	......
					Dry	41.62	45.81	12.57	4.66	.64	12330	14701
5277	27	7/12	Tazewell.......	5	14.71	37.46	38.57	10.26	3.51	1.15	10801	......
					Dry	44.06	44.03	11.91	4.07	1.33	12516	14500
5278	27	7/12	Tazewell.......	5	13.88	37.58	40.01	8.53	2.55	.95	11076	......
					Dry	43.64	46.45	9.91	2.96	1.10	12860	14499
5281	27	8/12	Tazewell.......	5	15.56	37.60	36.70	10.14	3.23	1.50	10552	......
					Dry	44.53	43.46	12.01	3.83	1.78	12496	14488
84483	108	3/22	Tazewell.......	5	15.4	35.1	40.4	9.1	2.6	1.26	10720	......
					Dry	41.5	47.8	10.7	3.0	1.49	12670	14261
84484	108	3/22	Tazewell.......	5	16.5	32.8	41.6	9.1	3.1	.57	10590	......
					Dry	39.3	49.8	10.9	3.7	.68	12690	14508
84485	108	3/22	Tazewell.......	5	15.4	35.2	39.8	9.6	4.2	.42	10670	
					Dry	41.6	47.1	11.3	5.0	.50	12610	15524

TABLE 2.—Analyses of mine samples not strictly indicative of commercial output—Continued.

[illegible]	[illegible]	[illegible]	County	[illegible]	Proximate analysis of coal as received, with total moisture, and dry or moisture free [illegible]	 Volatile matter	 Fixed carbon	 Ash	Sulphur	CO2	B.t.u.	Unit coal
					No. 5 Coal							
[illegible]	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.[illegible]	3.55	[illegible]	10754	----
					Dry	[illegible]	[illegible]	[illegible]	4.12	.41	12212	[illegible]
[illegible]	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.[illegible]	3.51	41	10745	----
					Dry	[illegible]	[illegible]	[illegible]	4.01	[illegible]	[illegible]	14199
[illegible]	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12325	[illegible]
[illegible]	19	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12482	[illegible]
[illegible]	19	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10482	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	44	[illegible]	14706
[illegible]	19	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12456	14343
[illegible]	20	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12323	[illegible]
[illegible]	20	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14448
[illegible]	20	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10735	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	21	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12455	[illegible]
[illegible]	21	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10951	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	22	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10842	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14340
[illegible]	22	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12444	[illegible]
[illegible]	22	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	22	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	[illegible]
25749	[illegible]	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Christian	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible]	[illegible]

[illegible] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. [illegible], p. [illegible], [illegible].

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—**Continued.**

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO$_2$	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5052	85	8/12	Clinton........	6	12.60 Dry	36.78 42.07	40.48 46.32	10.14 11.61	2.88 3.29	.77 .88	10827 12388	 14269
5053	85	7/12	Clinton........	6	12.15 Dry	37.74 42.96	40.52 46.13	9.59 10.91	3.51 3.99	.29 .33	10949 12464	 14256
5064	85	7/12	Clinton........	6	12.43 Dry	37.23 41.28	39.93 46.84	10.41 11.88	4.19 4.79	.38 .44	10730 12253	 14211
5073	84	7/12	Clinton........	6	13.32 Dry	37.43 43.18	39.02 45.02	10.23 11.80	4.06 4.68	.69 .80	10726 12374	 14336
5074	84	7/12	Clinton........	6	12.40 Dry	37.94 43.32	39.04 44.56	10.62 12.12	4.24 4.84	.58 .69	10796 12323	 14380
80744	198	8/21	Clinton.......	6	11.78 Dry	36.43 41.29	40.93 46.40	10.86 12.31	4.22 4.78	.63 .71	10771 12209	 14234
80745	198	8 21	Clinton........	6	11.40 Dry	36.59 41.30	41.07 46.35	10.94 12.35	3.74 4.22	.62 .70	10817 12209	 14887
80746	198	8 21	Clinton........	6	10.11 Dry	37.97 42.24	41.14 45.77	10.78 11.99	2.58 2.87	.60 .67	11064 12308	 14231
80767	199	8/21	Clinton.......	6	10.52 Dry	34.59 38.66	43.42 48.52	11.47 12.82	3.80 4.25	.35 .39	10953 12241	 13151
80768	199	8 21	Clinton........	6	11.73 Dry	35.25 39.93	43.87 49.70	9.15 10.37	3.48 3.94	.22 .25	11034 12500	 14201
80769	199	8 21	Clinton........	6	11.26 Dry	34.94 39.38	42.49 47.87	11.31 12.75	3.46 3.90	.77 .87	10774 12141	 14207
2856	[13]B. M. 46	2 06	Clinton........	6	11.64 Dry	35.41 40.07	44.29 50.13	8.66 9.80	3.41 3.86	....	11290 12776	 14415
2857	[13]B. M. 46	2 06	Clinton........	6	12.15 Dry	35.60 40.52	42.97 48.92	9.28 10.56	4.01 4.56	....	....	....
2991	[13]B. M. 46	2/06	Clinton........	6	11.35 Dry	34.62 39.05	40.63 45.83	13.40 15.12	4.76 5.37	....	10733 12107	 14312
2854	[13]B. M. 47	2,06	Clinton........	6	13.43 Dry	33.02 38.14	44.37 51.26	9.18 10.60	3.35 3.87	....	10037 12634	 14619
2855	[13]B. M. 47	2 06	Clinton........	6	12.73 Dry	33.35 38.21	44.32 50.79	9.60 11.00	3.60 4.13	....	....	....
2972	[13]B. M. 47	2 06	Clinton........	6	11.44 Dry	33.93 38.31	43.92 49.60	10.71 13.09	4.94 5.58	....	10958 12373	 14983
4384	[13]B. M. 48	1,07	Clinton........	6	14.45 Dry	29.76 34.79	46.16 53.95	9.63 11.26	2.09 2.44	. ...	....	....
4385	[13]B. M. 48	1/07	Clinton........	6	15.06 Dry	29.48 34.71	45.81 53.93	9.65 11.36	1.05 1.24	...	10726 12629	 14447
4785	53	4/12	Franklin.......	6	10.57 Dry	33.37 37.30	43.09 48.19	12.97 14.51	.83 .93	4.38 4.89	10714 11980	. 14236
4786	53	4,12	Franklin	6	10.00 Dry	32.80 36.45	50.92 56.59	6.27 6.96	.66 .73	.33 .36	12001 13334	. 14453
4787	53	4 12	Franklin.......	6	10.15 Dry	32.88 36.59	50.56 56.27	6.41 7.14	.59 .65	.22 .25	12000 13356	 14494

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[13] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull 22, pt 1, p 83, 1913.

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
12721	134	6/21	Franklin........	6	7.61	34.77	48.96	8.66	1.70	.05	12038	.....
					Dry	37.63	53.00	9.37	1.85	.05	12937	14559
12722	134	6/21	Franklin........	6	8.56	31.76	50.52	9.16	1.29	.32	11662	......
					Dry	34.73	55.26	10.01	1.41	.35	12683	14346
12729	136	6/21	Franklin........	6	6.72	35.94	46.32	11.02	3.11	.72	11599	...
					Dry	38.53	49.65	11.82	3.33	.78	12268	14365
12730	136	6/21	Franklin........	6	6.95	35.53	46.19	11.33	3.42	.51	11469	......
					Dry	38.18	49.65	12.17	3.68	.55	12444	14450
12731	136	6/21	Franklin......	6	8.36	32.98	51.49	7.17	1.28	.26	12070	......
					Dry	35.99	56.19	7.82	1.40	.28	13100	14430
12732	136	6/21	Franklin........	6	6.23	36.30	46.99	10.08	3.63	.39	11797	.....
					Dry	38.88	50.32	10.80	3.89	.42	12640	14433
12733	136	6/21	Franklin........	6	8.46	35.77	46.51	9.26	2.40	.15	11712	..
					Dry	39.08	50.80	10.12	2.73	.17	12607	14487
12734	136	6/21	Franklin........	6	7.52	34.46	48.88	9.14	1.20	.22	11895	......
					Dry	37.26	52.86	9.88	1.30	.24	12797	14440
30892	137	9/18	Franklin........	6	10.04	35.48	47.29	7.19	.77	......	11945	.
					Dry	39.44	52.57	7.99	.86	.....	13279	14608
30893	137	9/18	Franklin........	6	11.33	32.38	47.18	9.11	.59	..	11430	.
					Dry	36.52	53.21	10.27	.67	....	12892	14521
30894	137	9/18	Franklin........	6	9.04	36.20	47.86	6.90	1.28	....	12164	..
					Dry	39.80	52.61	7.59	1.41	....	13374	14615
30895	137	9/18	Franklin........	6	10.43	32.10	48.50	7.97	.52	..	11713	.
					Dry	36.95	54.15	8.90	.58	....	13075	14482
29741	138	2/18	Franklin........	6	9.73	34.19	48.97	7.09	1.08	...	11997	..
					Dry	37.88	54.27	7.85	1.20	.	13289	14559
29742	138	2/18	Franklin......	6	10.34	33.70	46.90	9.06	.54		11529	
					Dry	37.59	52.31	10.10	.60	...	12857	14451
29743	138	2/18	Franklin	6	9.28	34.17	48.77	7.78	.74	.	11885	
					Dry	37.67	53.75	8.58	.82	..	13100	14463
29744	138	2/18	Franklin........	6	9.17	34.29	49.15	7.39	1.17	....	12163	.
					Dry	37.75	54.11	8.14	1.29	..	13390	14723
29745	138	2/18	Franklin........	6	10.56	34.81	44.74	9.90	.45	.	11354	
					Dry	38.92	50.01	11.07	.50	.....	12695	14271
29746	138	2/18	Franklin......	6	10.36	32.12	47.21	10.31	.56	...	11326	
					Dry	35.83	52.67	11.50	.62	...	12634	14446
29754	138	2/18	Franklin	6	9.50	36.82	49.82	3.86	.79	..	12515	.
					Dry	40.69	55.04	4.27	.87		13829	13831
12682	139	6/21	Franklin........	6	7.06	35.69	45.24	12.01	3.50	.33	11487	.
					Dry	38.41	48.67	12.92	3.77	.35	12171	14494
12683	139	6/21	Franklin	6	10.07	32.64	50.15	7.14	.76	.22	11850	
					Dry	36.29	55.77	7.94	.85	.24	13177	14441
12684	139	6/21	Franklin........	6	8.28	34.98	49.38	7.36	1.13	.25	12047	
					Dry	38.14	53.84	8.02	1.24	.27	13072	14119
12698	139	6/21	Franklin	6	6.79	37.24	46.38	9.59	3.38	.31	11858	
					Dry	39.96	49.76	10.29	3.63	.33	12541	14430

TABLE 2.—*Analyses of [illegible] samples not exactly indicative of commercial output.*—Continued.

[illegible]	[illegible]	[illegible]	County	[illegible]	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free Moisture	 Volatile matter	 Fixed carbon	 Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	139	[illegible]	Franklin	6	8.07	33.86	49.71	8.37	1.02	.05	11906	------
					Dry	36.82	54.08	9.10	1.11	.05	12950	14429
20700	139	[illegible]	Franklin	6	6.98	36.53	44.77	11.72	3.95	.20	11390	------
					Dry	39.27	48.13	12.60	4.24	.22	12245	14567
[illegible]	140	[illegible]	Franklin	6	5.74	36.04	48.19	10.03	3.37	.36	11960	------
					Dry	38.23	51.13	10.64	3.57	.38	12509	14453
[illegible]	140	[illegible]	Franklin	6	6.64	36.34	48.38	8.64	2.75	.05	12043	------
					Dry	38.92	51.83	9.25	2.94	.05	12753	14444
[illegible]	140	[illegible]	Franklin	6	8.15	32.79	51.10	7.96	1.51	.14	11890	------
					Dry	35.70	55.63	8.67	1.64	.16	12963	14337
30885	141	10 18	Franklin	6	9.94	33.39	48.99	7.68	1.14	------	11880	------
					Dry	37.08	54.39	8.53	1.27	------	13192	14571
30886	141	10 18	Franklin	6	10.04	33.08	49.42	7.46	1.24	------	11898	------
					Dry	36.77	54.94	8.29	1.38	------	13226	14677
30884	141	10 18	Franklin	6	10.73	33.02	47.65	8.60	1.61	------	11637	------
					Dry	36.99	53.38	9.63	1.80	------	13036	14609
30883	141	10 18	Franklin	6	10.03	33.93	48.58	7.44	1.40	------	11884	------
					Dry	37.72	54.01	8.27	1.56	------	13210	14674
25442	142	[illegible]	Franklin	6	9.72	32.91	48.92	8.45	.87	------	11966	------
					Dry	36.45	54.19	9.36	.96	------	13144	14653
25443	142	[illegible]	Franklin	6	10.24	32.54	49.49	7.73	.90	------	11941	------
					Dry	36.25	55.14	8.61	.99	------	13304	14697
30887	143	10 18	Franklin	6	11.15	33.95	47.50	7.40	1.36	------	11734	------
					Dry	38.21	53.46	8.33	1.53	------	13207	14681
30888	143	10 18	Franklin	6	9.07	35.00	48.21	7.72	1.43	------	12019	------
					Dry	38.49	53.02	8.49	1.57	------	13219	14723
30889	143	10 18	Franklin	6	10.31	33.54	49.91	6.24	1.11	------	12053	------
					Dry	37.40	55.64	6.96	1.24	------	13441	14574
30867	144	4 18	Franklin	6	10.74	32.20	50.91	6.15	.83	------	12001	------
					Dry	36.07	57.04	6.89	.93	------	13444	14555
30868	144	4 18	Franklin	6	10.36	32.52	47.17	9.95	.63	------	11356	------
					Dry	36.28	52.62	11.10	.70	------	12668	14416
30869	144	4 18	Franklin	6	9.86	32.38	49.68	8.08	.93	------	11925	------
					Dry	35.92	55.12	8.96	1.03	------	13230	14682
30870	144	4 18	Franklin	6	10.91	32.32	50.89	5.88	.56	------	12049	------
					Dry	36.28	57.12	6.60	.63	------	13525	14548
12965	145	7 21	Franklin	6	8.33	31.23	51.35	9.09	1.24	.25	11846	------
					Dry	34.07	56.02	9.91	1.35	.27	12859	14512
12966	145	7 21	Franklin	6	8.17	32.54	50.60	8.69	1.20	.15	11942	------
					Dry	35.43	55.11	9.46	1.31	.17	12945	14525
12967	145	7 21	Franklin	6	8.46	32.93	50.99	7.62	.67	.08	11964	------
					Dry	35.98	55.70	8.32	.74	.08	13104	14472
20080	146	11 14	Franklin	6	9.33	31.15	50.36	9.16	.56	------	11806	------
					Dry	34.36	55.54	10.10	.62	------	13022	14636
20081	146	11 14	Franklin	6	10.01	29.93	50.08	9.98	.52	------	11522	------
					Dry	33.26	55.65	11.09	.58	------	12803	14564

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
20082	146	11/14	Franklin.......	6	9.25	31.03	51.02	8.70	.48	......	11857	......
					Dry	34.19	56.22	9.59	.53	......	13064	14478
20723	146	1/15	Franklin.......	6	8.21	32.46	49.00	10.33	.96	......	11770	..
					Dry	35.36	53.39	11.25	1.05	......	12823	14525
20724	146	1/15	Franklin.......	6	9.07	32.24	48.42	10.27	1.14	......	11606	......
					Dry	35.45	53.26	11.29	1.25	......	12764	14578
20725	146	1/15	Franklin.......	6	9.83	31.44	51.53	7.20	.50	......	11990	..
					Dry	34.87	57.15	7.98	.55	......	13297	14568
30877	147	10/18	Franklin.......	6	8.72	34.31	46.15	10.82	3.81	.....	11543	.....
					Dry	37.59	50.56	11.85	4.17	...	12645	14645
30878	147	9/18	Franklin.......	6	10.04	33.77	47.53	8.66	2.43	.....	11725	....
					Dry	37.54	52.83	9.63	2.70	......	13034	14791
30879	147	10/18	Franklin.......	6	9.67	33.32	46.67	10.34	3.07	......	11547	....
					Dry	36.89	51.66	11.45	3.40	.....	12784	14485
30880	147	10/18	Franklin.......	6	9.27	34.27	45.48	10.98	3.79		11461	.
					Dry	37.77	50.13	12.10	4.18	....	12632	14677
1695	[14]B. M. 9	/05	Franklin.......	6	10.28	32.04	49.74	7.94	1.06	....	....	..
					Dry	35.71	55.44	8.85	1.18	....	....	...
1694	[14]B. M. 9	/05	Franklin.......	6	9.46	33.55	48.87	8.12	1.63	.....	11990	.
					Dry	37.06	53.97	8.97	1.80	...	13243	14725
1786	[14]B. M. 9	/05	Franklin......	6	8.31	31.65	49.56	10.48	1.55	...	11727	....
					Dry	34.52	54.05	11.43	1.69	....	12789	14647
477D	[14]B. M. 10	8/08	Franklin.......	6	9.15	34.98	47.27	8.60	.99	....	......	......
					Dry	38.50	52.03	9.47	1.09	.....	.....	.....
478D	[14]B. M. 10	8/08	Franklin.......	6	8.59	32.15	51.03	8.23	1.29	...	12114	.
					Dry	35.17	55.83	9.00	1.41	....	13253	14728
496D	[14]B. M. 10	8/08	Franklin.......	6	8.12	34.46	48.79	8.63	1.13	.	12064	..
					Dry	37.51	53.10	9.39	1.23	......	13131	14654
495D	[14]B. M. 10	8/08	Franklin.......	6	8.61	33.19	46.82	11.38	.95	....	11585	.
					Dry	36.32	51.23	12.45	1.04	...	12676	14682
1648	[15]B. M. 11	8/08	Franklin.......	6	9.50	31.98	47.08	11.44	1.45	......	11506	..
					Dry	35.34	52.02	12.64	1.60	....	12713	14790
1871	[15]B. M. 12	7/06	Franklin.......	6	9.90	28.67	53.69	7.74	.48	.....	12001	...
					Dry	31.82	59.59	8.59	.53	.....	13320	14700
1872	[15]B. M. 12	7/06	Franklin.......	6	10.53	29.06	53.01	7.40	.47	...	.....	...
					Dry	32.48	59.25	8.27	.53	....	...	....
3408	[15]B. M. 12	7/06	Franklin.......	6	9.65	30.87	53.23	6.25	.45	....	.....	....
					Dry	34.17	58.91	6.92	.50	.....	..	....
1926	[15]B. M. 12	7/06	Franklin.......	6	14.91	26.66	49.50	8.93	.52	......	10958	.....
					Dry	31.33	58.18	10.49	.61	......	12879	14545
2020	[15]B. M. 12	7/06	Franklin.......	6	10.72	29.86	50.06	9.36	.91	......	11686	....
					Dry	33.45	56.07	10.48	1.02	......	13088	14794
3447	[15]B. M. 12	7/06	Franklin.......	6	9.58	29.18	50.24	11.00	.52	.....	11428	....
					Dry	32.27	55.56	12.17	.58	.....	12632	14561

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[14] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 83, 1913

[15] Ibid., p. 84.

[illegible] *not exactly indicative of commercial* [illegible]—*Continued.*

					Proximate analysis of coal [illegible] as received, with total moisture [illegible] Dry [illegible] moisture free							
			Coal		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.60	------	11685	------
					Dry	[illegible]	[illegible]	[illegible]	.56	------	12515	14503
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.52	------	11543	------
					Dry	[illegible]	[illegible]	[illegible]	.57	------	12587	14394
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.46	------	11961	------
					Dry	[illegible]	[illegible]	[illegible]	.52	------	13565	14547
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.60	------	11410	------
					Dry	[illegible]	[illegible]	[illegible]	.68	------	12993	14531
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.10	------	11950	------
					Dry	[illegible]	[illegible]	[illegible]	1.21	------	13172	14745
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.90	------	12083	------
					Dry	[illegible]	[illegible]	[illegible]	.98	------	13266	14767
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.91	------	12038	------
					Dry	[illegible]	[illegible]	[illegible]	.99	------	13203	14601
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	11988	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	13111	14706
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	11943	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	13088	14725
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	11970	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	13154	14675
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	13041	14556
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	11958	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	13039	14548
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	14612
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	[illegible]
[illegible]	[illegible]	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	[illegible]
[illegible]	[illegible]	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	[illegible]
[illegible]	B	M	Franklin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	.53	------	[illegible]	[illegible]
[illegible]	B	M	Franklin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.56	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	------	[illegible]	[illegible]
[illegible]	B	M	Franklin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.52	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	.58	------	[illegible]	[illegible]
[illegible]	B	M	Franklin	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.48	------	[illegible]	------
					Dry	[illegible]	[illegible]	[illegible]	.53	------	[illegible]	[illegible]

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[a] Fieldner, A. C., and others, Analyses of coal, U. S. Bureau of Mines Bull. 123, p. 33, 1918.

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—**Continued.**

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture * 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
20083	[16]B. M. 16	11/14	Franklin......	6	9.61	30.68	50.44	9.27	.50	......	11725	......
					Dry	33.94	55.80	10.26	.55	......	12971	14604
20723	[16]B. M. 17	11/14	Franklin......	6	8.21	32.46	49.00	10.33	.96	......	11770	......
					Dry	35.36	53.39	11.25	1.05	......	12823	14632
20724	[16]B. M. 17	11/14	Franklin......	6	9.07	32.24	48.42	10.27	1.14	......	11606	......
					Dry	35.45	53.26	11.29	1.25	......	12764	14578
20725	[16]B. M. 17	11/14	Franklin......	6	9.83	31.44	51.53	7.20	.50	......	11990	......
					Dry	34.87	57.15	7.98	.55	......	13297	14568
20726	[16]B. M. 17	11/14	Franklin......	6	8.87	32.72	49.05	9.36	.94	......	11785	......
					Dry	35.90	53.83	10.27	1.03	......	12931	14915
22915	[16]B. M. 18	8/15	Franklin......	6	9.78	32.29	49.73	8.20	1.02	......	11860	......
					Dry	35.79	55.12	9.09	1.13	......	13145	14613
22916	[16]B. M. 18	8/15	Franklin......	6	10.23	31.97	49.87	7.93	.91	......	11839	......
					Dry	35.61	55.56	8.83	1.01	......	13189	14613
22917	[16]B. M. 18	8/15	Franklin......	6	10.48	33.53	49.02	6.97	1.22	......	11932	......
					Dry	37.46	54.75	7.79	1.36	......	13329	14598
22918	[16]B. M. 18	8/15	Franklin......	6	8.86	33.27	49.48	8.39	.86	......	11970	
					Dry	36.50	54.29	9.21	.94		13133	14614
22919	[17]B. M. 19	8/15	Franklin......	6	10.48	31.87	49.10	8.55	1.16	......	11678	
					Dry	35.60	54.85	9.55	1.30	......	13046	14590
22920	[17]B. M. 19	8/15	Franklin......	6	10.16	32.66	49.63	7.56	.99	......	11921	
					Dry	36.35	55.23	8.42	1.10	......	13270	14634
22921	[17]B. M. 19	8/15	Franklin......	6	9.99	32.82	49.27	7.92	1.03	......	11857	
					Dry	36.46	54.74	8.80	1.14	......	13172	14593
26129	[18]B. M. 58	10/16	Franklin......	6	10.61	33.39	48.37	7.63	1.02	......	11855	
					Dry	37.35	54.11	8.54	1.14	......	13262	14646
30266	[18]B. M. 58	5/18	Franklin......	6	7.86	34.10	49.62	8.42	1.18		12141	
					Dry	37.01	53.85	9.14	1.28	......	13176	14709
30267	[19]B. M. 58	4/18	Franklin......	6	7.83	34.70	47.96	9.51	1.20	......	11963	
					Dry	37.65	52.03	10.32	1.30	......	12980	14651
30844	[19]B. M. 58	8/18	Franklin......	6	8.02	35.66	48.46	7.86	1.07	......	12128	
					Dry	38.77	52.68	8.55	1.16	......	13187	14566
31050	[19]B. M. 58	10/18	Franklin......	6	7.35	36.70	47.88	8.07	1.02	......	12164	
					Dry	39.61	51.68	8.71	1.10	......	13129	14526
29741	[19]B. M. 21	3/18	Franklin......	6	9.73	34.19	48.99	7.09	1.08	......	11997	
					Dry	37.88	54.27	7.85	1.20	......	13289	14582
29742	[19]B. M. 21	3/18	Franklin......	6	10.34	33.70	46.90	9.06	.54		11529	
					Dry	37.59	52.31	10.10	.60	......	12857	14449
29743	[19]B. M. 21	3/18	Franklin......	6	9.28	34.17	48.77	7.78	.74	......	11885	
					Dry	37.67	53.75	8.58	.82		13100	14465
29744	[19]B. M. 21	3/18	Franklin......	6	9.17	34.29	49.15	7.39	1.17	......	12163	
					Dry	37.75	54.11	8.14	1.29	......	[illegible]	14723

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[17] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 34, 1918.
[18] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 193, p. 30, 1922.
[19] Ibid., p. 31.

TABLE 2.—Analyses of [illegible] samples not exactly indicative of commercial output—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal: 1st, "As received," with total moisture; 2nd, "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
[illegible]	[illegible] B. M.	[illegible]	Franklin	4	[illegible]	[illegible]	44.73	[illegible]	.45	......	11354	......
	[illegible]				Dry	38.12	[illegible]	[illegible]	.50	......	12696	14433
[illegible]	[illegible] B. M.	[illegible]	Franklin	4	[illegible]	[illegible]	[illegible]	10.31	.56	......	11328	......
	[illegible]				Dry	[illegible]	[illegible]	11.50	.62	......	12634	14446
[illegible]	[illegible] B. M.	[illegible]	Franklin	4	[illegible]	[illegible]	[illegible]	3.96	.79	......	13515	......
	[illegible]				Dry	[illegible]	[illegible]	[illegible]	[illegible]	......	13829	14529
[illegible]	[illegible] B. M.	[illegible]	Franklin	4	[illegible]	[illegible]	[illegible]	10.96	1.06	......	11687	......
	2[illegible]				Dry	[illegible]	[illegible]	[illegible]	1.15	......	12654	14554
[illegible]	[illegible] B. M.	[illegible]	Franklin	4	[illegible]	[illegible]	[illegible]	10.63	1.10	......	11503	......
	2[illegible]				Dry	[illegible]	[illegible]	11.66	1.21	......	12731	14606
[illegible]	[21]B. M.	12 14	Franklin	4	9.54	32.91	48.41	9.14	.98	......	11772	......
	22				Dry	36.38	53.52	10.10	1.08	......	13014	14444
[illegible]	[21]B. M.	2 14	Franklin	4	[illegible]	33.25	[illegible]	7.01	1.08	......	12051	......
	22				Dry	36.77	55.48	7.75	1.19	......	13329	14585
[illegible]	[21]B. M.	12 14	Franklin	6	10.97	33.70	46.86	8.47	.99	......	11671	......
	22				Dry	37.85	52.64	9.51	1.11	......	13109	14812
[illegible]	[21]B. M.	2 14	Franklin	6	10.26	33.17	48.39	8.19	1.31	......	11858	......
	22				Dry	36.96	53.93	9.11	1.46	......	13214	14705
[illegible]	[21]B. M.	12 14	Franklin	6	9.68	32.90	48.35	9.07	1.09	......	11693	......
	22				Dry	36.43	53.53	10.04	1.21	......	12946	14280
[illegible]	[21]B. M.	4 16	Franklin	6	8.49	34.11	48.71	8.69	1.11	......	12064	......
	22				Dry	37.28	53.22	9.50	1.21	......	13153	14731
[illegible]	[21]B. M.	11 16	Franklin	6	8.05	34.51	47.67	9.77	1.06	......	11927	......
	22				Dry	37.53	51.85	10.62	1.15	......	12971	14635
35485	[21]B. M.	11 16	Franklin	6	9.66	34.06	47.27	9.01	1.17	......	11866	......
	22				Dry	37.70	52.33	9.97	1.30	......	13135	14650
30496	[21]B. M.	11 16	Franklin	6	10.04	33.61	48.01	8.34	1.10	......	11898	......
	22				Dry	37.36	53.37	9.27	1.22	......	13226	14739
5528	......	8 12	Gallatin	6	10.82	33.93	42.43	12.92	4.93	.42	11263	......
					Dry	37.94	47.57	14.49	5.53	.47	11609	15193
5510	223	8/12	Gallatin	6	4.47	33.33	47.73	11.46	3.59	.05	12320	......
					Dry	36.98	49.96	13.06	3.76	.05	12895	15157
5511	223	8 12	Gallatin	6	4.10	36.79	50.38	8.73	3.83	.04	12849	......
					Dry	38.36	52.54	9.10	3.99	.04	13397	15001
5513	223	8 12	Gallatin	6	12.55	34.81	46.34	6.30	5.61	.01	12015	......
					Dry	39.81	52.98	7.21	6.41	.01	13739	15129
23426	[21]B. M.	11/15	Gallatin	6	3.70	37.72	49.17	9.41	2.03	......	12987	......
	57				Dry	39.17	51.06	9.77	2.15	......	13487	15375
4773	55	4 12	Jackson	6	10.88	31.71	48.90	8.51	.65	.30	11594	......
					Dry	35.57	54.88	9.55	.73	.34	13009	14531
4790	55	4/12	Jackson	6	7.17	36.36	45.25	11.22	3.92	.43	11678	......
					Dry	39.18	48.74	12.08	4.22	.47	12581	14617

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[20] Ibid., p. 32.

[21] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 34, 1918.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO$_2$	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
4784	55	4, 12	Jackson.......	6	8.82	35.30	44.96	10.92	3.46	.50	11547	......
					Dry	38.72	49.30	11.98	3.79	.54	12663	14676
12647	183	6 21	Jackson........	6	10.34	35.71	45.74	8.21	1.03	.03	11585	......
					Dry	39.82	51.02	9.16	1.15	.03	12920	14376
12648	183	6 21	Jackson........	6	10.00	32.81	47.33	9.86	1.27	.07	11356	......
					Dry	36.46	52.58	10.96	1.41	.08	12618	14357
12649	183	6 21	Jackson........	6	9.16	34.31	46.76	9.77	1.24	.20	11523	......
					Dry	37.77	53.00	10.33	1.36	.22	12684	14317
12650	183	6 21	Jackson........	6	9.86	33.70	45.30	11.14	2.04	.27	11169	......
					Dry	37.38	50.26	12.36	2.26	.30	12391	14377
12651	183	6 21	Jackson	6	9.46	35.05	46.85	8.64	1.75	.07	11586	......
					Dry	38.71	51.75	9.54	1.93	.07	12796	14326
12652	183	6 21	Jackson........	6	9.66	35.94	45.96	8.44	1.28	.22	11583	......
					Dry	39.78	50.87	9.35	1.42	.24	12751	14307
2611	224	1, 10	Livingston	6	16.50	32.63	45.50	5.37	1.60	......	11297	......
					Dry	39.07	54.49	6.44	1.92	......	13529	14600
5086	66	7, 12	Macoupin.....	6	4.29	39.09	37.21	9.41	4.13	.32	10635	......
					Dry	45.60	43.42	10.98	4.82	.37	12408	14234
5087	66	7 12	Macoupin......	6	13.77	38.69	36.74	10.80	4.37	.62	10493	......
					Dry	44.86	42.62	12.52	5.07	.71	12169	14236
5088	66	7 12	Macoupin	6	14.73	38.33	37.24	9.70	4.50	.30	10522	......
					Dry	44.95	43.69	11.36	5.28	.35	12339	14237
5097	69	7 12	Macoupin.....	6	14.73	36.26	36.11	12.90	4.62	.28	10099	......
					Dry	42.53	42.34	15.13	5.42	.33	11843	14342
5098	69	7 12	Macoupin......	6	13.68	38.02	37.72	10.58	4.43	.21	10618	......
					Dry	44.05	43.70	12.25	5.12	.25	12300	14346
5099	69	7 12	Macoupin.....	6	14.19	37.92	37.03	10.86	4.21	.39	10599	......
					Dry	44.19	43.15	12.66	4.91	.45	12351	14476
5100	67	7 12	Macoupin.	6	15.12	38.28	36.55	10.05	3.85	.31	10610	......
					Dry	45.09	43.06	11.85	4.54	.37	12501	14488
5101	67	7 12	Macoupin	6	14.90	37.75	38.43	8.92	3.67	.45	10735	......
					Dry	44.35	45.16	10.49	4.31	.53	12614	14367
5102	67	7 12	Macoupin	6	14.67	35.49	38.83	11.01	4.15	.22	10433	......
					Dry	41.59	45.50	12.91	4.86	.26	12227	14370
5112	68	7, 12	Macoupin......	6	12.11	40.32	39.14	8.43	4.39	.38	11170	......
					Dry	45.88	44.52	9.60	5.00	.43	12705	14335
5113	68	7 12	Macoupin.....	6	13.27	38.58	38.15	10.00	4.89	.27	10790	
					Dry	44.48	43.99	11.53	5.64	.31	12442	14400
5114	68	7 12	Macoupin.....	6	13.23	38.85	38.91	9.01	4.39	.28	10435	......
					Dry	44.77	44.84	10.39	5.06	.32	12001	14359
81323	185	9 21	Macoupin.. ...	6	13.32	37.97	39.84	8.87	3.40	.31	10893	......
					Dry	43.80	45.97	10.23	3.92	.36	12567	14252
81324	185	9 21	Macoupin.....	6	12.41	37.96	39.98	9.65	3.57	.29	10889	......
					Dry	43.34	45.64	11.02	4.08	.33	12432	14241
81325	185	9 21	Macoupin......	6	9.84	42.13	39.51	8.52	3.51	.24	11426	......
					Dry	46.73	43.82	9.45	3.89	.27	12673	14237

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free: Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
18545	[24]B. M. 31	1/14	Macoupin......	6	12.90	37.80	39.77	9.53	4.23	....	10852	....
					Dry	43.40	45.66	10,94	4.86	.....	12460	14285
18546	[24]B. M. 31	1 14	Macoupin	6	14.16	35.53	40.21	10.10	3.70	.....	10615	.....
					Dry	41.39	46.84	11.77	4.31	.....	12366	14306
18553	[24]B. M. 31	1/14	Macoupin......	6	13.59	37.20	39.33	9.88	3.86	.....	10701	.....
					Dry	43.05	45.52	11.43	4.47	.....	12384	14272
18910	[24]B. M. 31	1/14	Macoupin......	6	13.38	36.88	37.50	13.24	5.05	.....	10361	....
					Dry	42.09	42.80	15.11	5.76	.....	11825	14329
5067	72	7/12	Madison.......	6	13.08	38.03	37.07	11.82	5.22	.25	10543	....
					Dry	43.75	42.65	13.60	6.01	.28	12129	14423
5068	72	7/12	Madison.......	6	13.53	37.26	40.98	8.23	3.81	.30	10903	....
					Dry	43.84	45.53	10.63	4.37	.23	12587	14363
5069	72	7/12	Madison.......	6	14.86	37.32	38.76	9.06	3.73	.20	10717	.
					Dry	43.84	45.53	10.63	4.37	.23	12587	14363
5070	71	7/12	Madison.......	6	12.99	37.73	36.89	12.39	4.43	.72	10499	....
					Dry	43.36	42.40	14.24	5.09	.82	12066	14440
5071	71	7/12	Madison.......	6	12.14	41.13	38.00	8.73	3.52	.41	11206	.
					Dry	46.82	43.24	9.94	4.00	.47	12759	14426
5072	71	7/12	Madison.......	6	12.42	39.82	37.65	10.11	4.35	.72	10649	...
					Dry	45.46	43.00	11.54	4.96	.80	12156	14398
5075	73	7/12	Madison.......	6	14.65	39.08	38.03	8.24	3.59	.29	10865	...
					Dry	45.80	44.55	9.65	4.20	.34	12730	14347
5076	73	7/12	Madison.......	6	14.31	38.35	38.32	9.02	3.77	.31	10739	
					Dry	44.75	44.72	10.53	4.40	.37	12532	14283
5078	73	7/12	Madison.......	6	15.18	38.40	38.30	8.12	3.94	.23	10751	
					Dry	45.27	45.16	9.57	4.64	.27	12673	14284
5515	70	8/12	Madison......	6	13.88	37.60	37.74	10.78	4.21	.53	10551	.
					Dry	43.65	43.82	12.53	4.89	.61	12250	14330
5517	70	8/12	Madison.......	6	12.44	39.10	38.20	10.26	5.23	.64	10818	
					Dry	44.65	43.64	11.71	6.03	.73	12354	14343
5518	70	8/12	Madison......	6	12.11	39.32	36.27	12.30	4.92	.47	10615	..
					Dry	44.74	41.26	14.00	5.60	.53	12076	14421
80942	191	8/21	Madison.......	6	13.76	37.50	37.63	11.71	4.52	.45	10556	
					Dry	43.18	43.34	13.48	5.20	.52	12156	14405
80943	191	8/21	Madison.......	6	13.76	39.10	37.39	9.75	2.89	.75	10805	..
					Dry	45.34	43.35	11.31	3.35	.87	12529	14382
80944	191	8/21	Madison......	6	12.01	38.41	38.46	11.12	3.68	.33	10763	
					Dry	43.65	43.71	12.64	4.18	.38	12232	14300
80962	192	8/21	Madison.......	6	11.71	37.44	40.57	10.28	4.32	.38	10936	
					Dry	42.41	45.95	11.64	4.89	.43	12386	14327
80963	192	8/21	Madison.....	6	11.19	38.00	40.84	9.97	4.12	.47	11066	
					Dry	42.79	45.98	11.23	4.64	.53	12460	14603
80964	192	8/21	Madison ..	6	12.02	35.62	41.79	10.57	3.69	.48	10888	.
					Dry	40.49	47.50	12.01	4.19	.55	12376	14604

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[24] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 34, 1918.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
1556	[25]B. M. 32	4/05	Madison........	6	17.02	30.60	35.59	16.79	3.29	------	9319	------
					Dry	36.88	42.89	20.23	3.96	------	11230	14900
1608A	[25]B. M. 32	4/05	Madison........	6	12.27	37.22	39.16	11.35	4.66	------	------	------
					Dry	42.43	44.63	12.94	5.31	------	------	------
1609	[25]B. M. 32	4/05	Madison........	6	11.87	36.57	39.98	11.58	4.75	------	10768	------
					Dry	41.50	45.36	13.14	5.39	------	12218	14422
1611	[25]B. M. 32	4/05	Madison........	6	11.46	34.98	36.25	17.31	4.40	------	10026	------
					Dry	39.51	40.94	19.55	4.97	------	11324	14541
1780	[25]B. M. 32	4/05	Madison........	6	10.83	36.24	39.75	13.18	4.53	------	10816	------
					Dry	40.64	44.58	14.78	5.08	------	12130	14616
1722	[26]B. M. 33	4/05	Madison........	6	10.69	33.08	36.14	20.09	4.06	------	9713	------
					Dry	37.04	40.47	22.49	4.55	------	10876	14560
2774	[26]B. M. 34	1/06	Madison........	6	13.07	34.85	42.02	10.06	3.59	------	10949	------
					Dry	40.09	48.34	11.57	4.13	------	12596	14533
2775	[26]B. M. 34	1/06	Madison........	6	12.79	35.67	40.25	11.29	3.94	------	------	------
					Dry	40.90	46.15	12.95	4.52	------	------	------
2819	[26]B. M. 34	1/06	Madison........	6	13.47	34.35	40.65	11.53	4.41	------	10510	------
					Dry	39.70	46.98	13.32	5.10	------	12126	14331
2803	[26]B. M. 34	1/06	Madison........	6	15.68	31.28	37.45	15.59	3.98	------	9655	------
					Dry	37.10	44.41	18.49	4.72	------	11450	14480
3911	[26]B. M. 35	10/06	Madison........	6	14.25	35.52	40.79	9.44	3.72	------	10892	------
					Dry	41.42	47.57	11.01	4.34	------	12703	14564
3913	[26]B. M. 35	10/06	Madison........	6	12.69	37.40	41.15	8.76	3.62	------	11236	------
					Dry	42.89	47.13	10.03	4.15	------	12868	14569
3963	[26]B. M. 35	10/06	Madison........	6	13.10	30.78	40.12	16.00	4.17	------	9983	------
					Dry	35.42	46.17	18.41	4.80	------	11488	14517
3958	[26]B. M. 35	10/06	Madison........	6	12.47	33.12	41.85	12.56	4.37	------	10667	------
					Dry	37.84	47.81	14.35	4.99	------	12186	14598
3980	[26]B. M. 35	10/06	Madison........	6	12.25	33.76	41.66	12.33	4.42	------	10719	------
					Dry	38.47	47.48	14.05	5.04	------	12215	14578
2772	[26]B. M. 36	1/06	Madison........	6	13.51	34.64	41.70	10.15	4.01	------	10881	------
					Dry	40.05	48.21	11.74	4.64	------	12580	14566
2773	[26]B. M. 36	1/06	Madison........	6	13.83	34.16	42.24	9.77	4.10	------	------	------
					Dry	39.64	49.02	11.34	4.76	------	------	------
2905	[26]B. M. 36	1/06	Madison........	6	11.91	35.65	39.43	13.01	5.34	------	10615	------
					Dry	40.47	44.76	14.77	6.06	------	12049	14551
2896	[26]B. M. 36	1/06	Madison........	6	13.03	32.65	39.79	14.53	4.35	------	10192	------
					Dry	37.54	45.75	16.71	5.01	------	11718	14479
1341	[26]B. M. 38	9/04	Madison........	6	15.09	31.00	46.49	7.42	.83	------	11151	------
					Dry	36.51	54.75	8.74	.98	------	13133	14533
1342	[27]B. M. 39	9/04	Madison........	6	14.42	32.18	44.59	8.81	1.52	------	------	------
					Dry	37.60	52.11	10.29	1.78	------	------	------
1417	[27]B. M. 39	9/04	Madison........	6	12.91	31.90	43.55	11.64	1.32	------	10804	------
					Dry	36.63	50.00	13.37	1.52	------	12406	14554

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[25] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 86, 1918.

[26] Ibid., p. 87.

[27] Ibid., p. 88.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO$_2$	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
2270	[28]B. M. 39	9/04	Madison.......	6	15.23	31.42	44.32	9.03	1.59	......	10901	......
					Dry	37.06	52.29	10.65	1.88	......	12859	14593
2271	[28]B. M. 39	9/04	Madison.......	6	17.79	28.78	42.34	11.09	1.40	......	......	......
					Dry	35.01	51.50	13.49	1.70	......	......	......
2852	[28]B. M. 39	9/04	Madison.......	6	15.54	31.26	42.27	10.93	1.38	......	10507	......
					Dry	37.01	50.05	12.94	1.63	......	12438	14432
2920	[28]B. M. 39	9/04	Madison.......	6	15.30	30.59	43.40	10.71	1.43	......	......	......
					Dry	36.12	51.24	12.64	1.69	......	......	......
10956	[29]B. M. 40	9/10	Madison.......	6	12.94	35.76	41.92	9.38	3.65	......	10973	......
					Dry	41.07	48.16	10.77	4.19	......	12604	14399
10957	[29]B. M. 40	9/10	Madison.......	6	12.31	37.57	41.09	9.03	3.58	......	11115	......
					Dry	42.84	46.86	10.30	4.08	......	12676	14395
10958	[29]B. M. 40	9/10	Madison.......	6	12.81	36.31	41.35	9.53	3.28	......	11023	......
					Dry	41.64	47.43	10.93	3.76	......	12641	14676
10959	[29]B. M. 40	9/10	Madison.......	6	12.70	36.36	41.47	9.47	3.67	......	10989	......
					Dry	41.65	47.50	10.85	4.20	......	12587	14396
5039	87	6/12	Marion.........	6	10.06	37.96	41.09	10.89	3.92	.59	11289	......
					Dry	42.21	45.69	12.10	4.35	.66	12555	14589
5041	87	6/12	Marion.........	6	10.35	36.04	42.81	10.80	4.10	.25	11227	.....
					Dry	40.20	47.75	12.05	4.57	.28	12522	14551
5044	87	6/12	Marion........	6	10.96	36.54	40.68	11.82	4.00	.43	11002	.....
					Dry	41.04	45.69	13.27	4.52	.48	12364	14583
80737	206	8/21	Marion.........	6	9.11	36.82	41.83	12.24	4.53	.32	11119	......
					Dry	40.51	46.02	13.47	4.98	.35	12233	14487
80738	206	8/21	Marion.........	6	9.05	37.00	41.78	12.17	4.63	.15	11143	.....
					Dry	40.68	45.94	13.38	5.42	.16	12252	14838
80739	206	8/21	Marion.........	6	9.19	36.90	41.94	11.88	3.39	.74	11243	.....
					Dry	40.73	46.19	13.08	3.73	.81	12381	14621
80740	206	8/21	Marion........	6	11.32	35.62	42.16	10.90	3.98	.10	11056	.....
					Dry	40.17	47.54	12.29	4.49	.11	12467	14528
80741	206	8/21	Marion.........	6	11.36	35.35	42.99	10.30	4.03	.15	11137	.....
					Dry	39.88	48.50	11.62	4.55	.17	12564	14521
80742	206	8/21	Marion.........	6	9.59	36.93	42.67	10.81	3.51	.44	11311	...
					Dry	40.85	47.19	11.96	3.88	.49	12511	14499
80695	207	8/21	Marion.........	6	9.87	35.92	44.41	9.80	3.65	.16	11494	.
					Dry	39.85	49.28	10.87	4.05	.18	12753	14587
80696	207	8/21	Marion........	6	10.63	37.26	42.04	10.07	2.87	.39	11259	...
					Dry	41.69	47.04	11.27	3.21	.44	12598	14451
80697	207	8/21	Marion.........	6	10.74	36.97	40.48	11.81	3.31	.76	11048	.
					Dry	41.42	45.35	13.23	3.71	.85	12377	14571
1725	[30]B. M. 52	6/05	Marion.........	6	10.25	37.43	39.79	12.53	3.70	....	11077	....
					Dry	41.70	44.34	13.96	4.12	......	12343	14690

[28] Ibid.
[29] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 85, p. 36, 1914.
[30] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 88, 1913.

TABLE 2. *Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

[illegible]	[illegible]	[illegible]	County	Coal bed	Proximate analysis of coal 1st. "As received," with total moisture 2nd: "Dry" or moisture free							
					Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
1576	U. S. B. M.[42]	[illegible]	Macon	6	11.88	35.84	43.45	8.83	3.25	------	------	------
					Dry	40.67	49.31	10.02	3.69	------	------	------
1581	U. S. B. M.[42]	[illegible]	Macon	6	9.95	34.76	42.06	13.23	3.87	------	10960	------
					Dry	38.60	46.71	14.69	4.30	------	12172	14639
[illegible]	76	[illegible]	Montgomery	6	14.15	36.96	38.19	10.70	3.43	.91	10547	------
					Dry	43.05	44.48	12.47	4.00	1.06	12285	14329
[illegible]	76	[illegible]	Montgomery	6	13.83	36.95	39.22	10.00	3.72	.91	10728	------
					Dry	42.88	45.51	11.61	4.32	1.05	12455	14382
[illegible]	76	[illegible]	Montgomery	6	13.70	37.25	37.93	11.12	4.39	1.04	10444	------
					Dry	43.17	43.94	12.89	5.08	1.20	12102	14225
[illegible]	77	[illegible]	Montgomery	6	14.00	36.88	40.02	9.10	3.84	.48	10761	------
					Dry	42.88	46.54	10.58	4.47	.57	12511	14266
S1101	104	S 21	Montgomery	6	12.84	37.08	40.56	9.52	3.58	.71	10894	------
					Dry	42.54	46.54	10.92	4.11	.81	12499	14302
S1102	104	S 21	Montgomery	6	13.28	36.02	40.55	10.15	4.15	.64	10671	------
					Dry	41.54	46.76	11.70	4.79	.74	12305	14239
S1103	104	S 21	Montgomery	6	13.46	35.80	41.36	9.38	4.48	.13	10774	------
					Dry	41.37	47.79	10.84	5.18	.16	12450	14268
S1095	105	S 21	Montgomery	6	12.65	36.14	41.55	9.66	3.87	.50	10793	------
					Dry	41.37	47.57	11.06	4.43	.57	12356	14171
S1094	105	S 21	Montgomery	6	11.66	37.25	41.31	9.78	3.69	.69	11053	------
					Dry	42.17	46.76	11.07	4.18	.78	12512	14345
S1093	105	S 21	Montgomery	6	14.32	34.82	41.97	8.89	3.94	.16	10687	------
					Dry	40.64	48.98	10.38	4.60	.19	12473	14530
S1089	106	S 21	Montgomery	6	11.38	37.05	40.98	10.59	4.26	.96	10832	------
					Dry	41.81	46.24	11.95	4.81	1.08	12223	14189
S1090	106	S 21	Montgomery	6	12.53	36.21	40.35	10.91	4.61	.85	10705	------
					Dry	41.40	46.13	12.47	5.27	.97	12258	14341
S1091	106	S 21	Montgomery	6	12.47	37.13	40.54	9.86	4.41	.40	10861	------
					Dry	42.42	46.32	11.26	5.04	.46	12408	14284
S1096	106	S 21	Montgomery	6	14.97	34.87	41.80	8.36	3.41	.44	10697	------
					Dry	41.01	49.16	9.83	4.01	.52	12580	14309
S1098	107	S 21	Montgomery	6	14.49	34.60	42.45	8.46	3.83	.36	10643	------
					Dry	40.46	49.65	9.89	4.48	.42	12446	14070
S1092	106	S 21	Montgomery	6	14.59	34.56	41.24	9.61	4.32	.47	10425	------
					Dry	40.51	48.23	11.26	5.06	.55	12220	14069
1581	U. S. B. M.[43]	[illegible]	Montgomery	6	12.90	33.77	42.25	11.08	3.78	------	10856	------
					Dry	38.77	48.51	12.72	4.34	------	12463	14598
1449	U. S. B. M.[43]	[illegible]	Montgomery	6	14.89	34.80	42.44	7.87	3.61	------	11016	------
					Dry	40.89	49.86	9.25	4.24	------	12944	14521
1450	U. S. B. M.[43]	[illegible]	Montgomery	6	13.94	34.03	41.22	10.81	3.79	------	------	------
					Dry	39.63	47.80	12.58	4.40	------	------	------
1337	U. S. B. M.[43]	[illegible]	Montgomery	6	14.43	29.48	42.81	13.28	4.01	------	10064	------
					Dry	34.45	50.03	15.52	4.69	------	11761	14280

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[43] Lord, N. W., and others, Analyses of coals. U. S. Bureau of Mines Bull. 22, pt. 1, p. 99, 1913.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
1702	[31]B. M. 43	5/05	Montgomery...	6	11.93	29.99	43.90	14.18	4.29	......	10303	......
					Dry	34.05	49.85	16.10	4.87	......	11698	14329
1627	[31]B. M. 43	5/05	Montgomery...	6	13.20	34.33	39.94	12.53	4.47	......	10614	......
					Dry	39.55	46.01	14.44	5.15	......	12112	14529
11352	[32]B. M. 44	11/10	Montgomery.	6	13.23	34.45	42.37	9.95	3.57	......	......	......
					Dry	39.70	48.83	11.47	4.11	......	......	......
11353	[32]B. M. 44	11/10	Montgomery...	6	12.99	32.86	40.33	13.82	4.06	......	......	......
					Dry	37.77	46.35	15.88	4.67	......	......	......
11354	[32]B. M. 44	11/10	Montgomery...	6	13.31	33.62	41.34	11.73	3.75	......	10548	......
					Dry	38.78	47.69	13.53	4.33	......	12168	14394
21901	[33]B. M. 45	4/15	Montgomery ..	6	14.87	33.42	40.70	11.01	3.26	......	10478	......
					Dry	39.26	47.81	12.93	3.83	......	12308	14419
21902	[33]B. M. 45	4/15	Montgomery...	6	12.70	35.52	40.16	11.62	4.15	.....	10669	......
					Dry	40.69	46.00	13.31	4.75	......	12220	14432
21903	[33]B. M. 45	4/15	Montgomery...	6	13.04	34.06	39.58	13.32	4.84	......	10301	......
					Dry	39.17	45.51	15.32	5.57	......	11846	14388
21904	[33]B. M. 45	4/15	Montgomery...	6	13.43	35.06	40.96	10.55	3.82	......	10732	......
					Dry	40.50	47.31	12.19	4.41	......	12398	14426
21905	[33]B. M. 45	4/15	Montgomery...	6	13.31	34.86	40.42	11.41	4.02	......	10620	......
					Dry	40.21	46.63	13.16	4.64	......	12251	14438
21906	[33]B. M. 46	4/15	Montgomery...	6	13.48	34.84	40.13	11.55	4.03	......	10548	......
					Dry	40.27	46.38	13.35	4.66	......	12191	14402
5254	225	8/12	Moultrie.......	6	7.07	39.02	43.01	10.90	3.69	.36	11912	......
					Dry	41.99	46.28	11.73	3.97	.39	12819	14736
5255	225	8/12	Moultrie.......	6	7.18	38.09	41.38	13.35	5.18	.46	11573	......
					Dry	41.03	44.59	14.38	5.58	.49	12468	14973
5256	225	8/12	Moultrie.......	6	6.24	40.34	42.55	10.87	3.18	.89	12149	......
					Dry	43.03	45.38	11.59	3.39	.95	12957	14937
4756	54	3/12	Perry..........	6	10.32	34.03	46.19	9.46	1.07	.24	11395	......
					Dry	37.94	51.51	10.55	1.18	.26	12705	14380
4759	54	3/12	Perry..........	6	10.41	33.43	45.82	10.34	.88	.23	11486	......
					Dry	37.32	51.14	11.54	.98	.25	12822	14367
4760	54	3/12	Perry..........	6	10.22	33.32	47.60	8.86	1.04	.23	11270	......
					Dry	37.11	53.03	9.86	1.15	.25	12553	14383
4764	54	3/12	Perry..........	6	9.98	33.71	44.91	11.40	.84	.33	11205	......
					Dry	37.45	49.88	12.67	.93	.37	12447	14452
4766	54	3/12	Perry.........	6	9.64	33.49	45.60	11.27	.82	.35	11230	......
					Dry	37.06	50.47	12.47	.90	.39	12428	14394
4768	54	3/12	Perry..........	6	10.05	33.24	45.85	10.86	.93	.63	11257	......
					Dry	36.94	50.98	12.08	1.04	.70	12513	14424
5034	90	6/12	Perry..........	6	10.60	37.03	42.32	10.05	3.73	.62	11175	......
					Dry	41.42	47.35	11.23	4.17	.70	12500	14365
5037	90	6/12	Perry..........	6	11.20	37.29	40.57	10.94	3.20	.34	10911	......
					Dry	42.00	45.69	12.31	3.60	.39	12287	14288

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[32] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 85, p. 37, 1914.
[33] Fieldner, A. C., and others, Analyses of coal. U. S. Bureau of Mines, Bull. 123, p. 35, 1918.

[illegible] *not exactly indicative of commercial output*—Continued.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Proximate analysis of coal: No. 1 "As received," with total moisture; No. 2 "Dry" or moisture free Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO2	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43.16	10.36	4.18	.47	11012	------
					[illegible]	[illegible]	[illegible]	11.58	4.67	.53	12317	14228
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.30	3.94	.38	11107	------
					[illegible]	[illegible]	[illegible]	10.40	4.34	.43	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.98	.76	11210	------
					[illegible]	[illegible]	[illegible]	11.12	3.34	.85	12570	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.71	.55	10826	------
					[illegible]	[illegible]	[illegible]	[illegible]	4.16	.52	12277	14319
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.43	10936	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.47	12067	14386
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.42	11099	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.56	12243	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.73	10915	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.81	12141	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.21	11063	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.25	12532	14422
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11357	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13015	14458
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14414
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11368	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14405
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11041	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—**Continued.**

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
12664	179	6/21	Perry..........	6	8.79	36.91	43.31	10.99	3.43	.19	11300	......
					Dry	40.47	47.48	12.05	3.76	.21	12201	14368
12665	179	6/21	Perry..........	6	8.88	37.82	42.73	10.57	3.38	.06	11290	......
					Dry	41.51	46.89	11.60	3.71	.06	12204	14287
12623	180	6/21	Perry..........	6	8.29	34.61	48.18	8.92	1.07	.25	11703	......
					Dry	37.74	52.54	9.72	1.17	.27	12761	14292
12624	180	6/21	Perry..........	6	8.91	33.28	47.11	10.70	.95	.05	11355	......
					Dry	36.53	51.72	11.75	1.04	.06	12466	14311
12614	180	5/21	Perry..........	6	10.00	32.79	48.99	8.22	.77	.12	11570	......
					Dry	36.44	54.43	9.13	.86	.14	12855	14288
12615	180	5/21	Perry..........	6	9.88	33.47	47.05	9.59	1.35	.43	11424	......
					Dry	37.14	52.22	10.64	1.50	.48	12678	14372
12616	180	5/21	Perry..........	6	9.49	34.09	46.22	10.20	1.21	.18	11432	......
					Dry	37.67	51.06	11.27	1.33	.20	12632	14425
31033	181	10/18	Perry..........	6	12.34	33.48	45.02	9.16	1.82	.....	11171	......
					Dry	38.19	51.36	10.45	2.08	.....	12744	14434
31034	181	10/18	Perry..........	6	12.19	24.16	44.50	9.15	1.32	.....	11245	......
					Dry	38.90	50.68	10.42	1.50	.....	12805	14479
31035	181	10/18	Perry..........	6	11.93	33.50	45.35	9.22	1.36	.....	11257	......
					Dry	38.04	51.49	10.47	1.54	.....	12782	14447
31036	181	10/18	Perry..........	6	11.86	34.13	44.63	9.38	1.46	.....	11236	......
					Dry	38.72	50.64	10.64	1.66	.....	12748	14426
12592	182	5/21	Perry..........	6	9.06	36.59	43.13	11.22	3.73	.37	11126	......
					Dry	40.24	47.43	12.33	4.10	.41	12235	14246
12593	182	5/21	Perry..........	6	9.00	35.80	44.03	11.17	3.86	.46	11097	......
					Dry	39.34	48.39	12.27	4.24	.51	12195	14194
12594	182	5/21	Perry..........	6	9.21	35.02	44.58	11.19	3.55	.40	11194	......
					Dry	38.57	49.10	12.33	3.91	.44	12327	14350
12588	184	5/21	Perry..........	6	8.13	38.22	42.61	11.04	3.73	.58	11296	......
					Dry	41.60	46.38	12.02	4.06	.64	12296	14262
12589	184	5/21	Perry..........	6	7.56	37.65	43.56	11.23	3.71	.52	11336	......
					Dry	40.73	47.12	12.15	4.01	.57	12263	14245
12590	184	5/21	Perry..........	6	8.28	39.19	41.95	10.58	3.49	.43	11406	......
					Dry	42.73	45.74	11.53	3.81	.47	12436	14329
12591	184	5/21	Perry..........	6	8.00	37.60	42.27	12.13	3.38	.57	11124	......
					Dry	40.87	45.95	13.18	3.67	.62	12091	14218
20728	[34]B. M. 29	10/15	Perry..........	6	10.88	32.97	47.20	8.95	1.15	.....	11380	......
					Dry	37.00	52.96	10.04	1.29	.....	12769	14411
20729	[34]B. M. 29	10/15	Perry..........	6	10.20	33.08	49.63	7.00	.80	.....	11749	......
					Dry	36.84	55.26	7.80	.89	.....	13082	14329
20730	[34]B. M. 29	10/15	Perry..........	6	11.47	32.05	48.44	8.04	.92	.....	11446	......
					Dry	36.20	54.72	9.08	1.04	.....	12929	14368
20731	[34]B. M. 29	10/15	Perry..........	6	10.64	32.78	48.93	7.65	.68	.....	11621	......
					Dry	36.68	54.76	8.56	.76	.....	13005	14152

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[34] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 35, 1918.

[illegible] *samples (not exactly indicative of commercial output)*—Continued.

[illegible]	[illegible]	[illegible]	County	[illegible]	Proximate analysis of coal 1st "As received," with total moisture 2nd "Dry" or moisture free Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO2	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.85	-----	11578	-----
					[illegible]	[illegible]	[illegible]	[illegible]	.96	-----	13088	14322
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.72	-----	11446	-----
					Dry	[illegible]	[illegible]	[illegible]	.81	-----	12859	14340
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.86	-----	11578	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	-----	13010	14426
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.83	-----	11729	-----
					Dry	[illegible]	[illegible]	[illegible]	.93	-----	13097	14475
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----	11598	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	14329
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----	11412	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	14485
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.80	-----	11494	-----
					Dry	[illegible]	[illegible]	[illegible]	.40	-----	[illegible]	[illegible]
		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	14497
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	-----
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	14514
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	-----	[illegible]	14542
[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.72	[illegible]	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	.81	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.42	10849	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	.47	12217	[illegible]
[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.41	[illegible]	-----
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-----
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12324	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11251	
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.52	10885	
					Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14458

[illegible]

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
12580	209	5/21	Randolph......	6	10.35	37.35	41.41	10.69	3.73	.51	10991	......
					Dry	41.75	46.30	11.95	4.17	.57	12287	14244
12581	209	5/21	Randolph......	6	8.95	36.48	41.87	12.70	4.72	.66	10874	......
					Dry	40.06	45.99	13.95	5.19	.73	11943	14233
12582	209	5/21	Randolph......	6	9.44	36.89	42.42	11.25	4.31	.75	11016	......
					Dry	40.73	46.84	12.43	4.76	.83	12165	14205
12570	210	5/21	Randolph......	6	9.62	36.49	42.58	11.31	3.61	.21	11215	......
					Dry	40.37	47.11	12.52	3.99	.23	12409	14485
12571	210	5/21	Randolph......	6	9.03	37.38	43.63	9.96	3.42	.39	11456	......
					Dry	41.09	47.96	10.95	3.76	.43	12593	14408
12572	210	5/21	Randolph......	6	9.27	35.55	43.78	11.40	3.10	.29	11230	......
					Dry	39.18	48.25	12.57	3.42	.32	12378	14439
12573	210	5/21	Randolph......	6	9.42	35.40	41.85	13.33	3.91	.41	10858	......
					Dry	39.08	46.20	14.72	4.32	.45	11987	14404
5115	75	8/12	Sangamon.....	6	14.97	36.90	38.36	9.77	3.53	.59	10598	......
					Dry	43.39	45.12	11.49	4.16	.67	12466	14361
5116	75	8/12	Sangamon.....	6	14.51	37.60	39.69	8.20	3.44	.22	10911	......
					Dry	43.98	46.43	9.59	4.02	.25	12763	14373
5117	75	8/12	Sangamon.....	6	12.98	38.23	38.92	9.87	4.32	.56	10845	......
					Dry	43.94	44.72	11.34	4.96	.65	12463	14368
5130	74	7/12	Sangamon.....	6	15.22	38.23	37.36	9.19	4.38	.38	10579	......
					Dry	45.09	44.07	10.84	5.17	.45	12478	14301
5131	74	7/12	Sangamon.....	6	13.10	38.86	37.25	10.79	5.08	.41	10592	......
					Dry	44.72	42.86	12.42	5.86	.47	12187	14268
5132	74	7/12	Sangamon.....	6	14.43	38.14	37.07	10.36	4.77	.40	10496	
					Dry	44.58	43.32	12.10	5.58	.47	12265	14292
81319	193	9/21	Sangamon.....	6	13.16	36.32	39.36	11.16	4.98	.51	10553	......
					Dry	41.82	45.33	12.85	5.73	.59	12152	14301
81320	193	9/21	Sangamon.....	6	13.25	36.73	40.75	9.27	3.53	.63	10884	......
					Dry	42.34	46.97	10.69	4.07	.73	12546	14314
81321	193	9/21	Sangamon.....	6	12.95	36.40	40.52	10.13	3.52	.56	1061	......
					Dry	41.82	46.54	11.64	4.04	.64	12427	14346
2897	[14]B. M. 42	2/06	Sangamon.....	6	14.29	37.17	40.36	8.18	4.41		11007	
					Dry	43.37	47.09	9.54	5.15		12841	14485
2898	[14]B. M. 42	2/06	Sangamon.....	6	14.18	34.85	41.11	9.86	4.36		.....	......
					Dry	40.61	47.90	11.49	5.08		.....	......
3052	[14]B. M. 42	2/06	Sangamon.....	6	16.00	32.41	37.82	13.77	4.05		9940	
					Dry	38.58	45.03	16.39	4.82		11833	14553
5056	79	7/12	St. Clair......	6	10.69	40.16	37.87	11.28	4.55	.58	11063	
					Dry	44.97	42.39	12.64	5.10	.65	12387	14522
5058	79	7/12	St. Clair......	6	12.12	38.61	40.61	8.66	3.10	.35	11217	......
					Dry	43.93	46.22	9.85	3.52	.40	12764	14399
5059	79	7/12	St. Clair......	6	11.12	40.54	38.27	10.07	4.18	.32	11145	
					Dry	45.61	43.06	11.33	4.70	.36	12540	14483

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[14] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 91, 1911.

[illegible] [illegible] mine samples (not exactly indicative of commercial output)—Continued.

Proximate analysis of coal
As received, with total moisture
Dry or moisture free

[illegible]	[illegible]	[illegible]	[illegible]	Fixed carbon	Ash	Sulphur	[illegible]	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.[illegible]	[illegible].21	[illegible].17	10741	......
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].70	1.[illegible]5	12354	14515
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.26	.56	10841	......
	[illegible]	[illegible]	[illegible]	[illegible]	3.23	4.[illegible]1	.54	12242	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].41	.57	11041	......
	[illegible]	[illegible]	[illegible]	[illegible]	2.[illegible]3	[illegible].92	.75	12371	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]5	.58	[illegible]	......
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]	.55	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	......
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]2554	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.46	[illegible]	......
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	......
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
12543	203	5/21	St. Clair.......	6	11.17	39.71	37.52	11.60	4.63	.69	10826	......
					Dry	44.70	42.24	13.06	5.21	.78	12187	14362
12544	203	5/21	St. Clair.......	6	10.59	39.83	39.99	9.59	4.09	.32	11103	......
					Dry	44.54	44.73	10.73	4.57	.36	12419	14192
12545	203	5/21	St. Clair.......	6	11.33	39.64	39.04	9.99	3.59	.18	11153	......
					Dry	44.70	44.03	11.27	4.05	.20	12578	14458
12546	203	5/21	St. Clair.......	6	10.00	40.32	40.28	9.40	4.43	.55	11386	......
					Dry	44.80	44.76	10.44	4.92	.61	12651	14422
12559	204	5/21	St. Clair.......	6	11.52	37.20	41.67	9.61	2.82	.10	11155	......
					Dry	42.05	47.09	10.86	3.19	.10	12607	14394
12556	205	5/21	St. Clair......	6	10.39	36.91	41.73	10.97	2.89	.74	11004	......
					Dry	41.19	46.57	12.24	3.23	.83	12280	14255
12557	205	5/21	St. Clair.......	6	9.26	37.77	41.08	11.89	3.01	.37	11170	......
					Dry	41.62	45.27	13.11	3.32	.41	12310	14438
12558	205	5/21	St. Clair.......	6	9.36	37.18	40.86	12.60	4.02	.55	10959	......
					Dry	41.02	45.08	13.90	4.44	.61	12091	14378
4250	[37]B. M. 49	11/06	St. Clair.......	6	13.17	34.79	41.75	10.29	3.22	...	......	......
					Dry	40.07	48.08	11.85	3.71	....	....	......
4251	[38]B. M 49	11/06	St. Clair.......	6	14.38	33.92	42.96	8.75	3.13	.. ..	10858	.
					Dry	39.62	50.16	10.22	3.66	......	12681	14373
4376	[38]B. M. 49	11 06	St. Clair.......	6	13.10	32.16	41.49	13.25	3.66	......	10393	. .
					Dry	37.01	47.74	15.25	4.21	....	11959	14465
1095	[39]B. M. 50	9,04	St. Clair.......	6	11.17	39.31	39.20	10.32	4.22	......	11223	..
					Dry	44.25	44.13	11.62	4.75	....	12634	14610
1096	[39]B. M. 50	9/04	St. Clair.......	6	10.06	40.33	39.54	10.07	4.04	.....	.....	. ..
					Dry	44.84	43.96	11.20	4.49	....	....	.....
1261	[39]B. M. 50	9,'04	St. Clair.......	6	9.75	37.48	39.57	13.20	4.10	....	11025	.
					Dry	41.53	43.84	14.63	4.54	...	12217	14672
1152	[39]B. M. 50	9/04	St. Clair.......	6	12.03	31.86	33.67	22.44	4.00	. ..	9149	
					Dry	36.22	38.27	25.51	4.55	. ...	10400	14541
3910	[39]B. M. 51	10,06	St Clair......	6	10.73	39.60	40.41	9.26	4.12	.....	.. .	......
					Dry	44.36	45.27	10.37	4.62	....	......	....
3912	[39]B. M. 51	10/06	St. Clair......	6	9.88	42.26	37.05	10.81	3.83	......	11439	. . .
					Dry	46.89	41.12	11.99	4.25	.....	12694	14733
4364	[39]B. M. 51	10 06	St. Clair.... ..	6	11.69	35.70	39.42	13.19	4.38	......	10699	... .
					Dry	40.43	44.63	14.94	4.96	.....	12116	14624
4670	93	2 12	Vermilion......	6	13.68	36.28	41.37	8.67	2.78	.45	11101	
					Dry	42.03	47.92	10.05	3.23	.52	12861	14537
4671	93	2/12	Vermilion......	6	15.50	33.32	43.11	8.07	1.86	.46	10976	. ..
					Dry	39.43	51.03	9.54	2.20	.62	12989	14558
4674	93	2/12	Vermilion......	6	15.69	34.52	42.22	7.57	1.56	.53	11019	.
					Dry	40.95	50.07	8.98	1.85	.63	13065	14553

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[37] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull 22, pt. 1, p 89, 1913

[38] Ibid., p. 90.

[39] Ibid., p. 89.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
4676	93	2/12	Vermilion......	6	14.56	35.04	41.82	8.58	2.09	.74	11006	------
					Dry	41.01	48.95	10.04	2.45	.86	12881	14527
4678	93	2/12	Vermilion......	6	16.06	34.67	40.75	8.52	1.79	.90	10810	------
					Dry	41.32	48.53	10.15	2.14	1.07	12879	14537
4679	93	2/12	Vermilion......	6	15.95	34.66	42.06	7.33	1.41	.39	11041	------
					Dry	41.23	50.05	8.72	1.68	.46	13136	14557
4702	92	3/12	Vermilion......	6	15.53	33.60	39.46	11.41	2.32	.98	10404	------
					Dry	39.78	46.70	13.52	2.75	1.15	12317	14520
4703	92	3/12	Vermilion......	6	15.70	32.38	39.80	11.36	2.57	1.06	10392	------
					Dry	38.81	47.72	13.47	3.04	1.26	12328	14535
4704	92	3/12	Vermilion......	6	15.27	33.98	40.88	9.87	2.26	.69	10718	------
					Dry	40.10	48.24	11.66	2.66	.81	12649	14563
4706	95	3/12	Vermilion......	6	11.87	40.37	39.52	8.24	3.07	.74	11416	------
					Dry	45.80	44.86	9.34	3.48	.84	12953	14525
4707	95	3/12	Vermilion......	6	13.14	38.81	38.11	9.94	4.18	.88	10949	------
					Dry	44.69	43.87	11.44	4.82	1.02	12604	14549
4740	91	6/12	Vermilion......	6	13.58	35.20	39.83	11.39	3.19	.83	10821	------
					Dry	40.73	46.09	13.18	3.69	.96	12521	14733
4741	91	6/12	Vermilion......	6	13.63	34.56	41.19	10.62	2.91	.78	10954	------
					Dry	40.01	47.69	12.30	3.36	.90	12683	14747
4742	91	6/12	Vermilion......	6	14.50	35.98	40.49	9.03	2.43	.44	11090	------
					Dry	42.09	47.35	10.56	2.83	.52	12971	14740
4743	91	6/12	Vermilion......	6	14.20	35.79	42.05	7.96	1.83	.34	11295	------
					Dry	41.71	49.01	9.28	2.13	.39	13165	14703
4744	91	6/12	Vermilion......	6	13.99	35.26	42.68	8.07	1.67	.98	11271	------
					Dry	40.99	49.63	9.38	1.94	1.14	13104	14706
4745	91	6/12	Vermilion......	6	14.79	34.44	42.69	8.08	1.72	.98	11053	------
					Dry	40.42	50.10	9.48	2.02	1.15	12971	14519
4746	91	6/12	Vermilion......	6	15.14	33.70	40.19	10.97	2.50	.61	10663	------
					Dry	39.72	47.34	12.94	2.95	.72	12565	14712
84222	212	2/22	Vermilion......	6	13.6	34.0	42.6	9.8	2.4	.83	11020	------
					Dry	39.3	49.5	11.2	2.8	.96	12750	14601
84223	212	2/22	Vermilion......	6	13.8	35.2	41.3	9.7	2.7	.69	11010	----
					Dry	40.8	48.0	11.2	3.1	.80	12760	14620
84224	212	2/22	Vermilion......	6	15.3	32.8	44.1	7.8	1.8	.80	11100	------
					Dry	38.7	52.1	9.2	2.1	.94	13110	14627
14682	[40]B. M. 53	/10	Vermilion......	6	16.16	34.09	39.19	10.56	1.74	------	10433	------
					Dry	40.66	46.75	12.59	2.08	------	12443	14472
25413	[41]B. M. 54	6/16	Vermilion......	6	15.62	35.59	39.97	8.82	1.68	------	10845	------
					Dry	42.18	47.37	10.45	1.99	------	12852	14554
5030	86	6/12	Washington....	6	12.45	37.22	39.81	11.52	3.62	.67	10874	------
					Dry	42.03	44.96	13.01	4.09	.76	12281	14426
5033	86	6/12	Washington....	6	10.24	39.06	39.79	10.91	4.18	.30	11180	------
					Dry	43.51	44.33	12.16	4.65	.34	12456	14499

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[40] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 85, p. 37, 1914.
[41] Fieldner, A. C., and others, Analyses of coal: U. S. Bureau of Mines Bull. 123, p. 35, 1918.

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5035	86	6/12	Washington....	6	10.69	38.76	39.01	11.54	3.98	.51	10963	......
					Dry	43.41	43.66	12.93	4.47	.57	12275	14418
80680	226	8/21	Washington....	6	9.58	38.50	39.87	12.05	4.63	.49	10906	......
					Dry	42.58	44.09	13.33	5.12	.54	12061	14260
80681	226	8/21	Washington....	6	9.41	39.02	40.33	11.24	3.59	.41	11172	......
					Dry	43.07	44.52	12.41	3.96	.45	12333	14374
80682	226	8/21	Washington....	6	9.29	38.45	38.94	13.32	4.70	.66	10796	......
					Dry	42.39	42.93	14.68	5.18	.73	11902	14321
80594	228	7/21	White..........	6	8.20	34.68	48.79	8.33	2.93	.73	12079	......
					Dry	37.78	53.15	9.07	3.19	.80	13158	14700
80595	228	7/21	White..........	6	7.66	36.01	45.62	10.51	2.75	.96	11701	......
					Dry	39.08	49.51	11.41	2.98	1.04	12699	14586
80596	228	7/21	White..........	6	9.22	35.05	47.88	7.85	2.89	.23	11991	......
					Dry	38.61	52.74	8.65	3.18	.25	13209	14677
4998	65	6/12	Williamson.....	6	9.35	32.83	50.07	7.75	1.05	.26	12017	......
					Dry	36.21	55.24	8.55	1.16	.29	13256	14644
5004	65	6/12	Williamson.....	6	9.99	33.79	48.56	7.66	.99	.06	11899	......
					Dry	37.53	53.96	8.51	1.10	.06	13218	14593
5005	65	6/12	Williamson.....	6	8.58	33.95	48.31	9.16	3.10	.14	11845	......
					Dry	37.14	52.84	10.02	3.39	.16	12956	14644
4996	60	6/12	Williamson.....	6	8.32	34.61	47.56	9.51	2.25	.24	11978	......
					Dry	37.75	51.88	10.37	2.46	.26	13066	14801
5000	60	6/12	Williamson.....	6	7.53	34.90	47.37	10.20	3.23	.60	11799	......
					Dry	37.74	51.23	11.03	3.49	.65	12760	14607
5006	60	6/12	Williamson.....	6	8.81	32.13	51.85	7.21	1.00	.13	11962	......
					Dry	35.62	56.38	8.00	1.11	.16	13264	14572
5121	61	6/12	Williamson.....	6	9.44	33.63	49.58	7.35	1.28	.19	12092	......
					Dry	37.13	54.75	8.12	1.42	.21	13354	14685
5133	61	7/12	Williamson.....	6	8.99	34.22	49.51	7.28	1.70	.04	12149	......
					Dry	37.62	54.39	7.99	1.87	.04	13349	14674
5134	61	7/12	Williamson.....	6	9.38	33.62	50.01	6.99	1.12	.14	12138	......
					Dry	37.10	55.18	7.72	1.24	.16	13394	14654
5122	59	7/12	Williamson.....	6	9.79	33.28	48.66	8.27	1.32	.44	11891	......
					Dry	36.89	53.94	9.17	1.46	.49	13181	14681
5123	59	7/12	Williamson.....	6	10.67	32.54	47.32	9.47	1.53	.15	11619	......
					Dry	36.42	52.97	10.61	1.71	.17	13006	14748
5124	59	7/12	Williamson.....	6	10.96	33.14	45.86	10.04	1.72	.55	11383	......
					Dry	37.24	51.49	11.27	1.93	.62	12784	14624
5125	62	7/12	Williamson.....	6	9.97	32.20	49.62	8.21	1.47	.22	11814	......
					Dry	35.76	55.12	9.12	1.63	.25	13123	14610
5126	62	7/12	Williamson.....	6	8.37	34.19	50.18	7.26	1.03	.18	12254	......
					Dry	37.31	54.77	7.92	1.12	.20	13374	14663
5127	62	7/12	Williamson.....	6	9.06	32.93	49.98	8.03	1.03	.24	12010	......
					Dry	36.20	54.97	8.83	1.13	.27	13207	14637
5170	64	7/12	Williamson.....	6	11.31	30.75	49.74	8.00	.84	.32	11554	
					Dry	34.76	56.20	9.04	.90	.36	13057	14501

[illegible] not exactly indicative of commercial [illegible]—continued.

[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.3	2944	------
								[illegible]	[illegible]	.6	3254	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	47	[illegible]	[illegible]	2017	------
								[illegible]	[illegible]	[illegible]	2274	1467
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1735	------
								[illegible]	[illegible]	[illegible]	3072	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1986	------
								[illegible]	[illegible]	[illegible]	3029	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
								[illegible]	[illegible]	14	3177	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13	[illegible]	------
								[illegible]	[illegible]	.4	3333	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	2015	------
								[illegible]	[illegible]	.16	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	------
								[illegible]	[illegible]	.59	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.21	[illegible]	[illegible]	------
								[illegible]	[illegible]	[illegible]	12312	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.35	12100	------
								[illegible]	[illegible]	.42	12885	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.45	[illegible]	------
								[illegible]	[illegible]	.46	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.25	[illegible]	------
								[illegible]	[illegible]	.27	12469	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.67	[illegible]	------
								[illegible]	[illegible]	.67	12528	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.46	[illegible]	------
								[illegible]	4.51	.46	12581	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.11	[illegible]	------
								[illegible]	[illegible]	.12	12964	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.14	[illegible]	------
								[illegible]	3.31	.15	12704	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.14	.16	[illegible]	------
								[illegible]	2.30	.17	13065	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.13	[illegible]	------
						Dry	[illegible]	[illegible]	1.24	.14	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	1.36	.73	[illegible]	------
						Dry	[illegible]	[illegible]	[illegible]	1.47	.81	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	1.44	.06	[illegible]	------
						Dry	[illegible]	[illegible]	[illegible]	1.55	.06	13242	14610
[illegible]	[illegible]	[illegible]		[illegible]	6	[illegible]	[illegible]	[illegible]	10.69	.90	------	11500	------
						Dry	[illegible]	[illegible]	11.76	.98	------	12656	14543
[illegible]	[illegible]	[illegible]		[illegible]	6	[illegible]	[illegible]	[illegible]	8.93	1.09	------	11973	------
						Dry	[illegible]	54.64	9.69	1.20	------	13023	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	6	[illegible]	33.36	51.37	5.52	.98	------	12290	------
						Dry	[illegible]	56.92	6.12	.98	------	13606	[illegible]

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
30875	153	10/18	Williamson.....	6	10.82 Dry	31.11 34.88	49.02 54.97	9.05 10.15	.88 .99	....	11646 13059	 14700
12799	154	6/21	Williamson.....	6	7.75 Dry	31.88 34.56	51.20 55.50	9.17 9.94	1.45 1.57	.18 .20	11987 12994	 14611
12800	154	6/21	Williamson.....	6	8.53 Dry	32.12 35.11	52.30 57.18	7.05 7.71	1.13 1.23	.17 .19	12253 13396	 14654
12801	154	6/21	Williamson.....	6	7.42 Dry	32.85 35.48	50.39 54.43	9.34 10.09	1.01 1.09	.18 .20	12084 12997	 14687
12752	155	6/21	Williamson.....	6	7.83 Dry	32.54 35.30	51.91 56.32	7.72 8.38	1.35 1.47	.14 .16	12092 13045	 14471
12753	155	6/21	Williamson.....	6	7.51 Dry	34.23 37.01	50.61 54.72	7.65 8.27	1.28 1.38	.15 .17	12179 13009	 14504
12754	155	6/21	Williamson.....	6	9.29 Dry	31.49 34.72	50.75 55.94	8.47 9.34	.93 1.03	.15 .16	11781 12987	 14480
12822	156	6/21	Williamson.....	6	8.38 Dry	31.25 39.11	53.08 57.93	7.29 7.96	1.12 1.22	.05 .05	12067 13171	 14449
12823	156	6/21	Williamson.....	6	9.18 Dry	31.10 34.25	52.33 57.61	7.39 8.14	1.32 1.45	.16 .18	11956 13164	 14468
12824	156	6/21	Williamson...	6	8.71 Dry	31.98 35.03	52.07 57.04	7.24 7.93	.94 1.03	.12 .14	12062 13213	 14483
12841	156	6/21	Williamson...	6	7.42 Dry	37.81 34.36	53.51 57.80	7.26 7.84	1.22 1.32	.07 .07	12190 13166	 14500
12842	156	6/21	Williamson.....	6	7.53 Dry	32.41 35.05	53.95 58.34	6.11 6.61	2.41 2.61	.22 .24	12416 13427	 14543
80598	157	7/21	Williamson.....	6	7.19 Dry	35.82 38.59	47.55 51.24	9.44 10.17	2.90 3.12	.26 .28	12074 13009	 14722
80599	157	7/21	Williamson....	6	8.17 Dry	35.03 38.15	46.87 51.04	9.93 10.81	3.08 3.35	.29 .30	11893 12951	 14782
80600	157	7/21	Williamson.....	6	9.25 Dry	32.70 36.03	50.57 55.73	7.48 8.24	1.52 1.67	.17 .19	12056 13285	 14650
12819	158	6/21	Williamson ...	6	7.47 Dry	32.15 34.75	51.38 55.52	9.00 9.73	2.37 2.56	.32 .35	11885 12845	 14551
12820	158	6/21	Williamson....	6	8.24 Dry	30.97 33.75	51.39 56.00	9.40 10.25	2.75 3.00	.00 .00	11776 12833	 14531
12821	158	6/21	Williamson.....	6	9.91 Dry	30.11 33.42	52.87 58.69	7.11 7.89	1.55 1.72	.02 .02	11923 13148	 14523
12796	159	6/21	Williamson.....	6	7.79 Dry	32.17 34.89	52.09 56.49	7.95 8.62	1.72 1.87	.06 .06	12157 13184	 14569
12797	159	6/21	Williamson.....	6	6.89 Dry	33.72 36.22	48.39 51.96	11.00 11.81	3.99 4.29	.25 .27	11568 12424	 14635
12798	159	6/21	Williamson.....	6	8.10 Dry	30.89 33.61	50.72 55.19	10.29 11.20	3.62 3.94	.04 .04	11717 12751	 14642
12868	160	7/21	Williamson ...	6	8.81 Dry	31.54 34.59	50.60 55.49	9.05 9.92	1.46 1.60	.06 .06	11783 12921	 14524
12869	160	7/21	Williamson	6	8.52 Dry	31.66 34.61	52.11 56.96	7.71 8.43	1.17 1.28	.07 .07	12034 13155	 14586

TABLE 2. Analyses of mine samples not exactly indicative of commercial output—Continued.

			County	Coal bed	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B.t.u.	Unit coal
					Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free							
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]8 Dry	34.57 37.12	49.39 53.04	[illegible].16 9.84	3.79 4.07	.02 .02	12022 12706	 14582
8810	[illegible]	[illegible]	Williamson	[illegible]	8.[illegible]1 Dry	32.40 35.34	50.75 55.35	8.54 9.31	1.33 1.45	....	11965 13048	 14553
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]3 Dry	31.48 34.64	51.00 56.13	8.39 9.23	.97 1.07	....	11922 13010	 14485
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]82 Dry	35.15 38.[illegible]5	47.90 52.53	8.13 8.92	1.07 1.17	....	11965 13122	 14557
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]31 Dry	32.43 [illegible]6.[illegible]1	49.63 54.73	8.13 8.[illegible]6	.82 .90	....	11902 13124	 14559
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]78 Dry	3[illegible] [illegible]6.[illegible]7	49.93 55.34	7.21 7.99	.75 .83	....	11965 13262	 14541
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]72 Dry	32.84 [illegible]6.[illegible]	50.55 56.10	6.79 7.52	.96 1.06	....	12026 13322	 14533
10864	[illegible]	[illegible]	Williamson	[illegible]	[illegible]40 Dry	34.78 37.95	47.35 52.26	8.87 9.79	1.28 1.41	....	11801 13027	 14614
10865	[illegible]	[illegible]	Williamson	[illegible]	[illegible]58 Dry	32.47 36.[illegible]1	46.30 51.78	10.65 11.91	1.57 1.76	....	11322 12661	 14590
[illegible]40	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	36.17 [illegible]	47.40 50.77	9.49 10.[illegible]7	3.06 3.30	....	12133 12985	 14713
[illegible]45	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	49.25 53.29	9.55 10.34	2.72 2.94	....	11974 12958	 14667
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible]1 Dry	35.21 [illegible]	47.38 [illegible]	11.10 11.81	3.54 3.77	....	11867 12526	 14464
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	11.48 12.[illegible]5	2.89 3.11	....	11668 12561	...... [illegible]
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	11.17 11.84	3.49 3.73	....	11921 12641	 14621
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	47.58 [illegible]	[illegible] 12.[illegible]	3.27 3.48	....	11768 12532	 14627
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	12.02 12.[illegible]7	3.07 3.31	....	11635 12553	 14725
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	12.44 [illegible]	4.21 4.50	1.01 1.08	11697 12511	...... [illegible]
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	[illegible] 10.43	[illegible] [illegible]	.60 .66	11819 [illegible]	...... [illegible]
[illegible]	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	7.49 8.21	[illegible] 1.01	.49 .54	12047 13212	...... [illegible]
12838	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	10.32 [illegible]	[illegible] [illegible]	.82 .88	11675 12508	 14564
12839	[illegible]	[illegible]	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	2.00 [illegible]	.21 .23	[illegible] [illegible]	...... [illegible]
12840	[illegible]	[illegible] 21	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	3.57 [illegible]	.64 .69	[illegible] [illegible]	...... [illegible]
12873	167	7 21	Williamson	[illegible]	[illegible] Dry	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] 1.25	.13 .14	12156 13164	...... [illegible]

TABLE 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
12876	167	7/21	Williamson.....	6	8.79	32.42	48.41	10.38	1.59	.48	11573	..
					Dry	35.54	53.08	11.38	1.74	.53	12688	14524
12877	167	7 21	Williamson....	6	6.47	34.62	49.61	9.30	2.92	.20	12046	
					Dry	37.01	53.05	9.94	3.12	.22	12723	14533
12881	168	7/21	Williamson.....	6	5.00	37.42	46.61	10.97	3.13	.28	12108	......
					Dry	39.39	49.06	11.55	3.29	.30	12580	14676
12882	168	7 21	Williamson	6	4.94	36.99	46.71	11.36	3.39	.44	12106	..
					Dry	38.91	49.14	11.95	3.57	.46	12557	14750
12883	168	7 21	Williamson....	6	5.73	35 37	44.97	13 93	4.17	.36	11514	.....
					Dry	37.52	47.71	14.77	4.42	.38	12215	14695
12772	169	6/21	Williamson	6	5.48	36 28	47.15	11.09	3.78	.61	11879	
					Dry	38.38	49.89	11.73	4.00	.65	12568	14545
12773	169	6/21	Williamson. ..	6	5.88	35.63	46.19	12 30	3.77	.45	11631	
					Dry	37.86	49.07	13.07	4.01	.47	12158	14529
12774	169	6 21	Williamson.....	6	6.95	34.41	48.47	10.17	4.02	.03	11848	
					Dry	36.98	52.09	10.93	4.32	.03	12517	14585
90625	170	7/21	Williamson. .	6	6.40	36.71	47.70	9.19	3.41	.04	12150	
					Dry	39.22	50.96	9.82	3.64	.04	12981	14644
90626	171	7 21	Williamson. ..	6	7.29	34 93	47.65	10.13	3.78	.04	11745	
					Dry	37.68	51.39	10.93	4.08	.04	12669	14334
90670	172	8/21	Williamson .	6	6.40	36.38	48.20	9 02	3 45	.04	12179	
					Dry	38.87	51.49	9.64	3 69	.04	13012	14648
90673	173	8 21	Williamson....	6	7.14	35.39	44.61	12 86	4 35	.63	11481	
					Dry	38.11	48.04	13 85	4.68	.68	12364	14708
90671	173	8 21	Williamson ..	6	6.24	36.41	44.45	12 90	3 56	.90	11672	
					Dry	38.83	47.41	13.76	3.80	.96	12449	14761
90672	173	8 21	Williamson....	6	7.49	36 37	46 95	9.19	2 73	.04	12080	
					Dry	39.31	50.76	9 93	2 95	.04	13058	14894
10632	[42]174	....	Williamson.	6	6.40	33.26	50 68	9.66	2 29		12109	
					Dry	35.53	54 15	10 32	2 45		12936	14642
10658	[42]174	2/19	Williamson..	6	7.47	33.79	49 41	9 33	1.77	...	11970	
					Dry	36.52	53.39	10.09	1 92	.	12933	14578
13537	227	3/22	Williamson....	6	9.09	31.33	52.10	8.42	1 09	.	11999	
					Dry	34.15	56.69	9.16	1.20		13199	14688
1683	[43]B M 23	6 05	Williamson ..	6	8.29	31.19	49.69	10 83	2 81	.	11837	
					Dry	34.01	54.18	11.81	3.06	..	12906	14903
1688	[43]B M 23	6 05	Williamson ..	6	8.41	34 27	45.44	11.88	3 63	...	.	...
					Dry	37.42	49 61	12.97	3 96	..		....
1762	[43]B. M 23	6 05	Williamson ...	6	8.20	32.26	46 59	12 95	3 48	.	11362	
					Dry	35.14	50.75	14.11	3 79	...	12377	14564

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[42] Analyses of a sample of forked coal.

[43] Lord, N. W., and others, Analyses of coals: U. S. Bureau of Mines Bull. 22, pt. 1, p. 91, 1913.

[illegible] *not exactly indicative of commercial* [illegible] —Continued.

[illegible] moisture free

Sulphur

[illegible]

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—**Continued.**

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
1171	[48]B. M. 26	6/05	Williamson.....	6	7.34	34.29	50.84	7.53	2.04	......	......	......
					Dry	37.01	54.86	8.13	2.20	......	......	......
1318	[48]B. M. 26	6/05	Williamson.....	6	8.50	29.47	50.75	11.28	1.72	......	11776	......
					Dry	32.21	55.46	12.33	1.88	......	12870	14916
19714	47	7/14	Williamson.....	7	7.28	32.03	50.00	10.69	1.91	......	11804	......
					Dry	34.54	53.93	11.53	2.06	......	12731	14612
17719	[48]B. M. 27	8/13	Williamson.....	6	8.77	32.64	51.41	7.18	1.10	......	12177	......
					Dry	35.78	56.35	7.87	1.21	......	13347	14626
17721	[48]B. M. 27	8/13	Williamson.....	6	8.70	31.78	51.89	7.63	1.00	......	12173	......
					Dry	34.81	56.83	8.36	1.10	......	13334	14694
17720	[48]B. M. 27	8/13	Williamson.....	6	9.37	32.83	49.63	8.17	1.70	......	11988	......
					Dry	36.22	54.77	9.01	1.88	......	13228	14717
28810	[49]B. M. 28	8/17	Williamson.....	6	8.31	32.40	50.75	8.54	1.33	......	11965	......
					Dry	35.34	55.35	9.31	1.45	......	13048	14553
28811	[49]B. M. 28	8/17	Williamson.....	6	9.13	31.48	51.00	8.39	.97	......	11822	......
					Dry	34.64	56.13	9.23	1.07	....	13010	14486
28812	[49]B. M. 28	8/17	Williamson.....	6	8.82	35.15	47.90	8.13	1.07	......	11965	......
					Dry	38.55	52.53	8.92	1.17	......	13122	14559
28813	[49]B. M. 28	8/17	Williamson.....	6	9.31	32.93	49.63	8.13	.82	......	11902	......
					Dry	36.31	54.73	8.96	.90	......	13124	14559
28814	[49]B. M. 28	8/17	Williamson.....	6	9.78	33.08	49.93	7.21	.75	......	11965	......
					Dry	36.67	55.34	7.99	.83	......	13262	14381
No. 7 Coal.												
5416	99	8/12	LaSalle........	7	13.82	41.42	35.90	8.86	3.95	.51	11174	......
					Dry	48.06	41.67	10.27	4.58	.59	12966	14744
5414	99	8/12	LaSalle........	7	12.87	42.40	37.35	7.38	3.86	.00	11468	
					Dry	48.67	42.86	8.47	4.44	.00	13161	14635
5417	99	8/12	LaSalle........	7	13.99	38.81	40.12	7.08	3.23	.00	11401	
					Dry	45.12	46.65	8.23	3.76	.00	13255	14675
4711	94	3/12	Vermilion......	7	12.20	39.53	38.38	9.89	3.76	.46	11243	
					Dry	45.03	43.70	11.27	4.28	.52	12804	14730
4713	94	3/12	Vermilion......	7	12.70	39.20	39.24	8.86	2.79	.52	11399	
					Dry	44.90	44.95	10.15	3.19	.59	13057	14776
4714	94	3/12	Vermilion......	7	12.76	38.84	38.31	10.09	3.91	.61	11156	
					Dry	44.53	43.91	11.56	4.48	.70	12788	14773
4716	94	3/12	Vermilion.....	7	12.67	39.01	37.43	10.89	3.54	.84	11041	
					Dry	44.67	42.86	12.47	4.06	.96	12644	14734
4722	94	3/12	Vermilion......	7	13.53	37.39	39.57	9.51	3.20	.46	11045	
					Dry	43.24	45.76	11.00	3.70	.54	12773	14622
4724	94	3/12	Vermilion......	7	13.27	37.25	40.65	8.83	3.27	.38	11209	
					Dry	42.95	46.87	10.18	3.77	.44	12925	14650

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[47] Fieldner, A. C., and others, Analyses of coals: U. S. Bureau of Mines Bull. 123, p. 36, 1918. Run of mine sample. Not included in averages.

[48] Ibid, p. 36.

[49] U. S. Bureau of Mines, unpublished analyses.

Table 2.—*Analyses of mine samples (not exactly indicative of commercial output)*—Concluded.

Laboratory number	Index number	Date	County	Coal bed	Proximate analysis of coal 1st: "As received," with total moisture 2nd: "Dry" or moisture free				Sulphur	CO^2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
4727	97	3/12	Vermilion......	7	12.92 Dry	36.98 42.46	38.94 44.73	11.16 12.81	2.90 3.33	.70 .80	10924 12544	 14715
4734	97	3/12	Vermilion......	7	13.10 Dry	38.42 44.22	39.14 45.03	9.34 10.75	2.26 2.59	.56 .64	11281 12981	 14778
4736	97	3/12	Vermilion......	7	13.41 Dry	37.33 43.11	38.87 44.89	10.39 12.00	2.54 2.93	.46 .53	11065 12778	 14787
84226	211	2/22	Vermilion......	7	13.1 Dry	37.7 43.4	38.8 45.8	9.4 10.8	2.8 3.2	.59 .69	11110 12770	 14564
84227	211	2/22	Vermilion......	7	14.1 Dry	37.0 43.1	39.3 45.7	9.6 11.2	2.9 3.4	.86 1.0	11030 12840	 14727
84228	211	2/22	Vermilion......	7	13.7 Dry	37.0 42.9	39.5 45.7	9.8 11.4	3.2 3.7	.70 .81	11060 12800	 14724

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts.*

DISTRICT NO. 1—BUREAU CO., NO. 2 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
1	16.19 Dry	37.79 45.06	38.06 45.40	8.00 9.54	3.24 3.86	.82 .98	10787 12869	 14476
8	16.50 Dry	38.48 46.08	37.59 45.02	7.43 8.90	2.40 2.90	1.16 1.39	10868 13016	 14493
10	16.13 Dry	38.82 46.28	38.36 45.74	6.69 7.98	3.15 3.76	.70 .84	10994 13108	 14463
Average	16.27 Dry	38.35 45.80	38.00 45.39	7.38 8.81	2.93 3.50	.89 1.40	10883 12997	 14477

DISTRICT NO. 1—GRUNDY CO., NO. 2 COAL

5	16.01 Dry	39.32 46.83	38.51 45.84	6.16 7.33	2.75 3.28	1.32 1.57	11104 13221	 14463
6	19.53 Dry	37.59 46.71	37.94 47.15	4.94 6.14	2.01 2.61	.70 .87	10818 13444	 14447
7	16.29 Dry	38.46 45.94	40.53 48.42	4.72 5.64	2.17 2.59	.48 .57	11394 13613	 14579
Average	17.28 Dry	38.48 46.49	39.02 47.14	5.27 6.37	2.33 2.82	.83 1.00	11113 13426	 14496

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts.*—Continued.

DISTRICT NO. 1—LA SALLE CO., NO. 2 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
2	14.60	39.88	36.97	8.55	3.97	.81	10904	....
	Dry	46.70	43.29	10.01	4.65	.95	12768	14475
3	15.05	39.76	37.00	8.19	3.30	.59	10899	....
	Dry	46.80	43.56	9.64	3.88	.69	12830	14448
9	17.45	38.98	34.52	9.04	3.18	1.49	10391	....
	Dry	47.22	41.82	10.95	3.85	1.81	12587	14402
102	14.7	34.9	42.3	8.06	3.26	.73	11056	....
	Dry	40.9	49.6	9.46	3.86	.84	12960	14892
103	12.4	39.40	41.27	6.65	2.61	....	11779	....
	Dry	44.99	47.10	7.90	2.97	....	13448	14805
B. M.	13.93	36.78	40.34	8.93	3.45	....	11192	....
1	Dry	46.87	46.87	10.37	4.00	....	12883	14767
Average	14.58	38.28	42.01	8.23	3.29	.90	11020	....
	Dry	45.58	45.37	9.72	3.86	1.06	12912	14632

DISTRICT NO. 1—MARSHALL CO., NO. 2 COAL

4	16.93	37.57	39.57	5.93	2.53	.37	11188	....
	Dry	45.22	47.64	7.14	3.05	.44	13468	14696
11	13.28	40.58	37.71	8.43	3.04	.60	11435	....
	Dry	46.80	43.48	9.72	3.51	.69	13186	14896
Average	15.10	39.06	38.68	7.16	2.79	.48	11315	....
	Dry	46.01	45.56	8.43	3.28	.56	13327	14796

EXTRA SAMPLE—LA SALLE CO., NO. 5 COAL

	14.76	41.33	34.26	9.65	3.38	.61	10692	....
	Dry	48.49	40.19	11.32	3.97	.71	12543	14397

DISTRICT NO. 1—LIVINGSTON CO., NO. 5 COAL

215	9.40	35.69	41.09	13.80	4.74	....	11258	....
	Dry	40.05	45.35	15.26	5.24	....	12422	15084
216	13.76	36.00	38.96	11.50	3.15	....	10850	....
	Dry	41.48	45.18	13.34	3.66	....	12581	14836
Average	11.58	35.84	40.02	12.65	3.94	....	11054	....
	Dry	40.26	45.26	14.30	4.45	....	12501	14960

DISTRICT No. 1—LA SALLE CO., NO. 7 COAL

99	13.56	40.87	37.80	7.77	3.68	.17	11347	....
	Dry	47.28	43.73	8.99	4.26	.20	13127	14685

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—**Continued.**

DISTRICT NO. 2—JACKSON CO., NO. 2 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
12	9.62	33.02	51.09	6.27	1.13	.69	12260	....
	Dry	36.53	56.53	6.94	1.25	.76	13565	14705
13	10.18	33.40	51.90	4.52	.97	.29	12614	....
	Dry	37.18	57.79	5.03	1.08	.32	14044	14888
14	8.56	34.18	50.25	7.01	1.54	.09	12418	....
	Dry	37.39	54.95	7.66	1.68	.10	13581	14864
15	8.70	34.77	51.34	5.19	1.42	.09	12651	....
	Dry	38.08	56.23	5.69	1.55	.12	13856	14815
16	9.34	34.55	50.52	5.59	1.40	.26	12490	....
	Dry	38.11	55.72	6.17	1.54	.29	13777	14820
104	4.56	36.32	45.22	13.90	7.12	.03	11778	....
	Dry	38.06	47.38	14.57	7.47	.03	12167	14927
Average	8.49	34.37	50.05	7.08	2.26	.24	12368	....
	Dry	37.55	54.76	7.67	2.42	.27	13498	14836

DISTRICT NO. 3—CHRISTIAN CO., NO. 1 COAL

21	11.31	38.89	40.94	8.86	2.35	.43	11602	....
	Dry	43.85	46.16	9.99	2.65	.48	13081	14717

DISTRICT NO. 3—FULTON CO., NO. 1 COAL

105	11.21	38.41	40.16	10.20	4.96	.62	11466	....
	Dry	43.26	45.23	11.50	5.58	.70	12914	14950

DISTRICT NO. 3—MERCER CO., NO. 1 COAL

17	17.63	39.13	34.13	9.11	5.02	.70	10336	....
	Dry	47.51	41.44	11.05	6.09	.85	12548	14373
18	14.58	39.07	37.00	9.35	4.79	.21	10890	....
	Dry	45.74	43.31	10.95	5.61	.25	12737	14640
19	14.52	39.26	36.32	9.90	4.24	.68	10809	....
	Dry	45.93	42.49	11.58	4.96	.80	12645	14624
Average	15.58	39.17	35.80	9.45	4.69	.53	10673	....
	Dry	46.40	42.41	11.19	5.55	.63	12643	14546

DISTRICT NO. 3—McDONOUGH CO., NO. 2 COAL

22	17.40	33.30	41.47	7.82	2.02	.27	10811	....
	Dry	40.31	50.23	9.48	2.45	.33	13091	14663
213	15.86	35.08	40.27	8.79	3.86	....	10798	....
	Dry	41.69	47.85	10.45	4.58	....	12832	14621
Average	16.63	34.19	40.37	8.31	2.94	....	10804	....
	Dry	41.00	49.04	9.96	3.51	....	12961	14642

TABLE 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 3—SCHUYLER CO., NO. 2 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
214	14.53	37.83	42.08	7.54	4.54	....	11731	....
	Dry	43.26	48.11	8.62	5.19	....	13411	14967

DISTRICT NO. 4—McLEAN CO., NO. 2 COAL

100	11.26	42.21	37.73	8.80	3.03	.98	11566	....
	Dry	47.57	42.52	9.91	3.41	1.10	13034	14714
B. M.	10.06	35.93	39.16	14.83	2.97	....	11149	....
55	Dry	39.95	43.55	16.49	3.31	....	12422	15028
Average	10.66	39.07	38.44	11.81	3.00	....	11357	....
	Dry	43.76	43.03	13.20	3.36	....	12728	14871

DISTRICT NO. 4—FULTON CO., NO. 5 COAL

28	16.68	36.68	36.76	9.88	2.90	1.36	10375	....
	Dry	44.02	44.12	11.86	3.48	1.63	12452	14403
29	16.38	35.96	36.88	10.78	3.47	1.02	10230	....
	Dry	43.01	44.10	12.89	4.15	1.22	12234	14349
30	16.18	35.17	37.77	10.88	3.06	1.53	10296	....
	Dry	41.96	45.06	12.98	3.65	1.82	12284	14402
31	16.88	36.32	36.32	10.48	2.98	1.25	10269	....
	Dry	43.70	43.70	12.61	3.58	1.50	12355	14424
32	14.66	37.24	37.71	10.39	3.28	1.54	10651	....
	Dry	43.64	44.18	12.18	3.84	1.81	12481	14502
110	15.43	33.62	39.47	11.48	2.50	1.41	10389	....
	Dry	39.76	46.67	13.57	2.66	1.67	12285	14473
111	14.61	34.06	38.64	13.22	3.03	2.22	10130	....
	Dry	39.88	46.25	14.86	3.55	2.60	11865	14289
112	15.26	35.88	38.61	11.12	2.79	1.54	10522	....
	Dry	41.30	45.56	13.12	3.29	1.78	12818	14596
113	14.25	34.79	39.19	11.75	3.18	1.45	10622	....
	Dry	40.57	45.71	13.71	3.71	1.69	12383	14656
114	14.81	35.86	38.43	10.88	2.89	1.60	10123	....
	Dry	37.10	45.11	12.78	3.40	1.87	12265	14339
115	15.25	33.50	40.50	10.25	3.10	1.16	10610	....
	Dry	39.50	47.80	12.70	3.70	1.37	12530	14580
116	15.69	35.03	38.29	10.97	3.88	.51	10467	....
	Dry	41.55	45.43	13.01	4.61	.61	12416	14609
117	13.5	34.4	38.8	13.3	3.5	....	10410	....
	Dry	39.8	44.8	15.4	4.1	....	12040	14589
118	12.78	38.60	30.32	11.53	3.80	1.03	10903	....
	Dry	40.40	49.66	13.26	4.36	1.18	12296	14746
Average	15.88	35.50	37.68	11.40	3.16	1.35	10428	....
	Dry	41.15	45.58	13.53	3.72	1.58	12335	14496

TABLE 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 4—LOGAN CO., NO. 5 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
33	14.20	37.19	37.44	11.37	3.34	1.42	10490	....
	Dry	43.35	43.40	13.25	3.89	1.66	12226	14400
109	13.53	35.58	40.82	10.06	2.95	1.05	10924	....
	Dry	41.14	47.20	11.64	3.09	1.15	12633	14590
B. M.	15.32	32.52	39.81	12.34	3.70	....	10371	....
37	Dry	38.41	47.01	14.57	4.37	....	12234	14671
Average	14.35	35.09	39.35	11.25	3.33	1.23	10595	....
	Dry	37.96	45.87	13.15	3.78	1.40	12364	14553

DISTRICT NO. 4—MACON CO., NO. 5 COAL

41	14.48	36.00	38.05	11.47	3.32	.90	10445	....
	Dry	42.10	44.49	13.41	3.88	1 05	12214	14420
42	13.83	37.35	39.62	9.20	3.83	.09	10877	....
	Dry	43.34	45.98	10.68	4.45	.11	12623	14418
123	12.82	35.45	43.07	8.64	3.23	.13	11010	....
	Dry	40.67	49.41	9.91	3.71	.15	12668	14305
Average	13.71	36.26	40.24	9.77	3.46	.37	10777	....
	Dry	42.03	46.62	11.33	4.01	.43	12501	14381

DISTRICT NO. 4—McLEAN CO., NO. 5 COAL

100	13.32	38.00	36.21	12.47	3.73	1.20	10580	....
	Dry	43.84	41.78	14.38	4.30	1.39	12206	14604

DISTRICT NO. 4—MENARD CO., NO. 5 COAL

34	17.33	35.88	38.62	8.17	3.44	.50	10499	....
	Dry	43.40	46.72	9.88	4.16	.60	12700	14478

DISTRICT NO. 4—PEORIA CO., NO. 5 COAL

25	14.92	36.92	37.21	11.02	3.44	1.21	10951	....
	Dry	43.30	43.74	12.95	4.04	1.42	12448	14614
26	15.00	36.48	36.75	11.77	3.08	1.80	10421	....
	Dry	42.91	43.24	13.85	3.62	2.12	12260	14614
106	13.40	30.33	44.80	11.46	3.80	1.05	10736	....
	Dry	35.03	51.76	13.20	4.40	1.20	11980	14670
107	10.73	34.56	39.96	11.36	2.96	1.77	10673	....
	Dry	40.16	46.60	13.23	3.40	2.05	12423	14617
B. M.	15.45	32.05	40.11	14.54	3.84	....	10732	....
2	Dry	40.87	47.45	17.18	4.29	....	12693	14687
B. M.	15.38	34.34	38.65	11.63	2.90	....	10414	....
3	Dry	40.58	45.65	13.74	3.43	....	12415	14575
Average	14.14	34.11	39.58	11.96	3.33	1.45	10654	....
	Dry	40.47	46.40	14.02	3.86	1.69	12369	14629

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 4—SANGAMON CO., NO. 5 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
36	15.34	36.54	37.83	10.29	3.67	.59	10519	....
	Dry	43.16	44.68	12.16	4.33	.70	12425	14450
37	13.78	37.82	37.69	10.73	4.11	.47	10625	....
	Dry	43.86	43.71	12.44	4.77	.55	12323	14396
38	14.26	38.07	37.48	10.19	4.14	.37	10649	....
	Dry	44.40	43.71	11.89	4.83	.43	12420	14410
39	13.31	37.43	36.66	12.60	4.72	.94	10398	....
	Dry	43.17	42.29	14.54	5.45	1.09	11995	14420
40	15.06	36.69	38.15	10.10	4.08	.59	10584	....
	Dry	43.19	44.92	11.89	4.80	.69	12460	14403
119	14.06	35.85	39.54	10.54	3.74	.43	10686	....
	Dry	41.71	46.01	12.26	4.31	.50	12434	14479
120	13.62	36.81	39.24	10.32	3.93	.79	10786	....
	Dry	42.62	45.42	11.95	4.55	.92	12487	14452
121	10.73	34.55	40.77	10.28	3.75	.45	10741	....
	Dry	40.30	47.83	11.96	4.37	.52	12491	14502
122	13.15	35.62	41.28	9.93	3.90	.62	10812	....
	Dry	41.02	47.54	11.44	4.49	.72	12449	14434
B. M.	13.70	34.47	40.58	11.23	3.81	....	10696	....
41	Dry	39.95	47.03	13.01	4.42	....	12332	13969
Average	13.70	36.38	38.92	10.62	3.98	.51	10650	....
	Dry	42.33	45.31	12.32	4.63	.68	12381	14391

DISTRICT NO. 4—TAZEWELL CO., NO. 5 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
27	14.38	37.74	38.23	9.66	3.10	1.20	10809	....
	Dry	44.08	44.65	11.28	3.62	1.40	12624	14496
108	15.76	34.36	40.60	9.26	3.30	.75	10660	....
	Dry	40.80	48.23	10.76	3.90	.89	12656	14764
Average	15.07	36.05	39.41	9.46	3.20	.97	10734	....
	Dry	42.44	46.44	11.02	3.76	1.14	12640	14630

DISTRICT NO. 5—GALLATIN CO., NO. 5 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
47	5.72	35.77	46.71	11.80	3.47	1.01	12053	....
	Dry	37.94	49.54	12.52	3.68	1.07	12784	14919
Extra	4.13	34.21	52.80	8.86	3.23	.02	12987	....
	Dry	35.68	55.07	9.25	3.37	03	13546	15175
135	3.96	35.38	50.23	10.41	3.37	.25	12601	....
	Dry	36.84	52.31	10.85	3.51	.26	12997	14997
Average	4.60	35.12	49.91	10.36	3.36	.43	12547	....
	Dry	36.82	52.31	10.87	3.52	.45	13309	15030

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 5—SALINE CO., NO. 5 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
43	6.97	35.98	49.69	7.36	2.05	.32	12550	....
	Dry	38.68	53.41	7.92	2.20	.34	13490	14829
44	6.70	35.31	49.55	8.44	2.56	.02	12401	....
	Dry	37.85	53.11	9.04	2.74	.02	13291	14824
45	7.03	34.78	50.27	7.92	2.48	.26	12420	....
	Dry	37.41	54.07	8.52	2.67	.28	13359	14806
46	7.96	34.68	48.54	8.82	2.79	.46	12077	....
	Dry	37.68	52.74	9.58	3.03	.50	13122	14741
48	7.67	33.90	50.26	8.17	2.56	.70	12234	....
	Dry	36.72	54.43	8.85	2.77	.76	13250	14739
49	5.20	38.06	45.90	10.84	4.60	.59	12193	....
	Dry	40.15	48.42	11.43	4.85	.62	12862	14824
124	6.83	33.25	51.85	8.03	2.24	.22	12435	....
	Dry	35.70	55.67	8.62	2.40	.23	13353	14806
125	6.59	33.50	52.08	7.82	2.37	.09	12526	....
	Dry	35.87	55.75	8.37	2.54	.09	13743	14831
126	6.01	34.05	52.34	7.58	2.56	.16	12582	....
	Dry	36.23	55.70	8.06	2.61	.16	13341	14784
127	5.68	33.78	52.85	7.94	2.13	.42	12614	....
	Dry	35.82	55.75	8.42	2.26	.44	13708	14780
128	6.51	32.24	51.31	9.93	1.87	.06	12175	....
	Dry	34.48	54.87	10.63	2.01	.06	13022	14782
129	5.98	34.17	52.82	7.02	2.01	.09	12715	....
	Dry	36.34	56.21	7.47	2.17	.09	13524	14840
130	6.22	33.33	51.47	8.96	2.71	.16	12339	....
	Dry	35.54	54.89	9.56	2.83	.17	13358	14772
B. M.	7.61	32.64	51.65	8.24	2.08	....	12225	....
5	Dry	35.05	55.99	8.95	2.22	....	13316	15208
B. M.	5.78	33.39	52.81	8.01	2.26	....	12718	....
6	Dry	35.44	56.06	8.50	2.72	....	13498	15120
B. M.	7.07	34.56	51.07	7.29	2.15	....	12560	....
7	Dry	37.19	54.95	7.85	2.31	....	13516	15120
B. M.	4.83	38.49	46.74	9.73	4.03	....	12441	....
8	Dry	40.65	49.12	10.22	4.23	....	13073	14842
Average	6.08	34.37	51.05	8.47	2.83	.22	12521	....
	Dry	36.61	54.36	9.02	2.96	.24	13377	14922

DISTRICT NO. 5—GALLATIN CO., NO. 6 COAL

Extra	7.54	34.96	45.68	11.82	4.34	.23	11916	....
	Dry	37.81	49.41	12.78	4.70	.25	12888	15136
223	7.04	34.97	48.15	8.83	4.37	.03	12394	....
	Dry	38.38	51.82	9.79	4.72	.03	13677	15095
Average	7.29	34.96	46.91	10.33	4.36	.13	12155	....
	Dry	38.09	50.61	11.29	4.71	.14	13283	15115

TABLE 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

EXTRA SAMPLE—GALLATIN CO., COAL MARKED "BELL"

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
	3.40	33.33	55.18	8.09	4.25	.03	13401	....
	Dry	34.50	57.12	8.38	4.40	.03	13872	15420

DISTRICT NO. 5—WHITE CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
228	8.36	35.24	47.43	8.89	2.85	.64	11923	....
	Dry	38.49	51.80	9.71	3.11	.69	13022	14654

DISTRICT NO. 6—FRANKLIN CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
50	9.34	34.84	48.03	7.79	1.04	.38	12004	....
	Dry	38.42	52.99	8.59	1.15	.42	13241	14633
51	10.28	33.42	49.05	7.25	1.18	.10	11890	....
	Dry	37.26	54.66	8.08	1.32	.11	13252	14562
52	6.77	38.35	44.62	10.26	3.13	.91	11875	....
	Dry	41.14	47.85	11.00	3.36	.98	12737	14554
53	10.18	32.78	48.88	8.16	.64	.61	11661	....
	Dry	36.50	54.41	9.09	.71	.68	12983	14419
56	8.10	36.30	45.34	10.26	2.51	.74	11826	....
	Dry	39.50	49.34	11.16	2.73	.80	12758	14601
57	9.67	35.69	49.55	8.54	.95	.32	11756	....
	Dry	32.24	54.86	9.45	1.05	.35	13015	14529
58	8.93	34.51	48.80	7.76	.74	.36	11937	....
	Dry	37.89	53.59	8.52	.81	.40	13108	14463
134	8.28	33.23	47.34	8.80	1.26	.20	11962	....
	Dry	36.22	54.17	9.59	1.38	.22	12885	14487
136	7.37	35.16	47.39	9.66	2.50	.37	11757	....
	Dry	37.98	51.57	10.43	2.72	.40	12602	14433
137	10.21	34.29	47.70	7.79	.79	....	11813	....
	Dry	35.67	53.13	8.65	.88	....	13155	14556
138	9.84	34.30	47.93	7.91	.76	....	11824	....
	Dry	39.09	53.16	8.78	.84	....	13113	14392
139	7.87	35.15	47.60	9.36	2.28	.22	11790	....
	Dry	38.14	51.70	10.14	2.47	.24	14351	14461
140	6.84	35.05	49.22	8.87	2.54	.18	11984	....
	Dry	37.61	52.86	9.52	2.71	.19	12708	14412
141	10.19	33.35	48.66	7.79	1.11	....	11824	....
	Dry	37.14	54.18	8.68	1.50	....	13166	14632
142	9.98	32.72	49.20	8.09	.83	....	11903	....
	Dry	36.34	54.66	8.98	.92	....	13224	14675
143	10.18	34.19	48.54	7.12	1.30	....	11936	....
	Dry	36.74	54.04	7.92	1.44	....	12827	14700
144	10.46	32.35	49.66	7.51	.73	....	11807	....
	Dry	36.13	55.47	8.38	.82	....	13216	14550
145	8.48	32.16	50.88	8.46	1.03	.16	11917	....
	Dry	35.16	55.45	9.24	1.13	.17	12969	14503

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 6—FRANKLIN CO., NO. 6 COAL—Concluded.

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
146	9.28	31.39	50.06	9.27	.69	....	11908	....
	Dry	38.84	55.18	10.21	.76	....	12962	14558
147	8.42	33.91	46.45	10.20	3.27	....	11569	....
	Dry	37.43	51.29	11.25	3.61	....	12773	14649
B. M. 9	9.35	32.41	49.39	8.84	1.41	....	11858	....
	Dry	35.76	52.92	9.75	1.55	....	13016	14686
B. M. 10	8.61	33.69	48.47	9.21	1.09	....	11921	....
	Dry	36.87	53.04	10.07	1.19	....	13020	14688
B. M. 11	9.50	31.98	47.08	11.44	1.45	....	11506	....
	Dry	35.34	52.02	12.64	1.60	....	12713	14780
B. M. 12	10.63	28.83	52.03	8.48	5.53	....	11585	....
	Dry	32.26	58.24	9.49	6.20	....	12734	14909
B. M. 13	9.00	34.27	48.08	8.64	1.06	....	11980	....
	Dry	37.66	52.83	9.50	1.17	....	13165	14712
B. M. 14	9.18	33.93	48.51	8.36	.92	....	11911	....
	Dry	37.36	53.42	9.37	1.01	....	13116	14620
B. M. 15	9.96	32.86	49.06	8.11	.80	....	11901	....
	Dry	36.49	54.49	9.01	.89	....	13215	14672
B. M. 16	7.14	30.69	50.47	9.27	.51	....	11727	....
	Dry	33.93	55.80	10.26	.57	....	12964	14602
B. M. 17	8.99	32.21	49.75	9.29	.88	....	11788	....
	Dry	35.39	54.40	11.94	.97	....	12953	14673
B. M. 18	9.83	32.76	49.52	7.87	1.00	....	11901	....
	Dry	36.34	54.93	8.73	1.11	....	13199	14609
B. M. 19	10.21	32.45	49.33	8.01	1.02	....	11152	....
	Dry	36.13	54.94	8.92	1.18	....	13162	14605
B. M. 20	8.25	31.30	49.65	10.79	1.08	....	11645	....
	Dry	34.11	54.12	11.76	1.18	....	12128	14580
B. M. 21	9.84	34.58	47.93	7.91	.76	....	11824	....
	Dry	38.04	53.16	8.78	.84	....	13113	14514
B. M. 22	9.58	33.58	48.20	8.63	1.09	....	11866	....
	Dry	37.14	53.31	9.54	1.21	....	13125	14640
B. M. 58	8.33	34.91	48.45	8.29	1.09	....	12050	....
	Dry	38.07	52.87	9.05	1.18	....	13146	14618
Average	9.11	33.53	48.59	8.68	1.39	.37	11815	....
	Dry	36.75	53.57	9.61	1.54	.41	13023	14590

DISTRICT NO. 6—JACKSON CO., NO. 6 COAL

55	8.96	34.44	46.40	10.20	2.65	.40	11609	....
	Dry	37.83	50.97	11.20	2.91	.44	12751	14608
183	9.74	34.58	46.62	9.34	1.43	.14	11467	....
	Dry	38.32	51.58	10.28	1.58	.15	12693	14343
Average	9.35	34.51	46.51	9.77	2.04	.27	11538	....
	Dry	38.07	51.27	10.74	2.24	.29	12722	14475

TABLE 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—**Continued.**

DISTRICT NO. 6—PERRY CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
54	9.92	32.72	46.97	10.39	.92	.25	11335	....
	Dry	36.81	52.15	11.53	1.02	.28	12583	14407
175	10.14	35.64	43.76	10.45	3.66	.36	11356	....
	Dry	39.67	48.70	11.63	4.08	.40	12455	14379
178	9.77	34.99	42.19	12.70	4.09	.32	10815	....
	Dry	38.78	47.13	14.06	4.54	.34	11987	14330
179	8.83	37.36	43.02	10.78	3.40	.12	11295	....
	Dry	40.99	47.18	11.82	3.73	.13	12202	14327
180	9.31	33.64	47.51	9.52	1.07	.20	11596	....
	Dry	37.10	52.39	10.50	1.18	.23	12278	14337
181	12.08	33.81	44.87	9.22	.99	....	11227	....
	Dry	38.46	51.04	10.49	1.69	....	12769	14446
B. M	10.96	32.52	48.64	7.86	.85	....	11542	....
29	Dry	36.53	54.63	8.83	.96	....	12963	14365
Average	10.14	34.38	45.28	10.13	2.14	.25	11309	....
	Dry	38.33	50.46	11.26	2.45	.27	12462	14370

DISTRICT NO. 6—WILLIAMSON CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
59	10.47	32.99	47.27	9.27	1.52	.38	11630	....
	Dry	36.85	52.80	10.35	1.70	.43	12990	14684
60	8.22	34.00	48.79	8.99	2.16	.33	11959	....
	Dry	37.04	53.16	9.80	2.35	.36	13030	14660
61	9.27	33.83	49.70	7.20	1.37	.13	12127	....
	Dry	37.28	54.78	7.94	1.51	.14	13366	14671
62	9.13	33.09	49.94	7.84	1.17	.22	12028	....
	Dry	36.42	54.95	8.63	1.29	.24	13236	14637
63	9.47	33.45	48.13	8.95	1.94	.36	11852	....
	Dry	36.96	53.16	9.88	2.14	.40	13092	14730
64	9.34	32.77	49.48	8.41	.92	.52	11872	....
	Dry	36.15	54.58	9.27	1.01	.57	13095	14577
65	9.31	33.52	48.98	8.19	1.70	.13	11919	....
	Dry	36.96	54.01	9.03	1.88	.14	13143	14627
148	7.99	33.48	50.15	8.37	1.21	.15	12129	....
	Dry	36.39	54.51	9.09	1.32	.16	13183	14664
149	6.31	35.09	47.86	10.73	3.08	.43	11931	....
	Dry	37.45	51.11	11.43	3.28	.49	12738	14697
150	5.98	35.00	47.69	11.29	4.00	.26	11786	....
	Dry	37.23	50.72	12.01	4.25	.27	12536	14550
151	6.91	36.41	47.09	9.59	2.78	.10	12015	....
	Dry	39.11	50.58	10.30	2.99	.11	12907	14625
152	7.03	32.26	51.63	9.07	1.32	.31	12117	....
	Dry	34.70	55.53	9.75	1.42	.33	13009	14617
153	9.63	32.30	49.54	8.52	.91	....	11824	....
	Dry	37.49	54.83	9.43	1.01	....	13056	14607
154	7.90	32.28	51.29	8.52	1.19	.17	12108	....
	Dry	35.05	55.70	9.24	1.29	.19	13129	14530
155	8.21	32.75	51.09	7.94	1.18	.14	12017	....
	Dry	35.67	55.66	8.66	1.29	.16	13043	14485
156	8.24	32.91	52.98	7.05	1.40	.12	12150	....
	Dry	34.56	57.74	7.28	1.54	.13	13202	14448

[illegible] analyses and heat values for separate mines and by [illegible] according to districts—Continued.

[illegible] CO., NO. 6 COAL—Concluded.

[illegible]	[illegible]	[illegible]	[illegible]	Ash	Sulphur	CO₂	B. t. u.	"Unit coal"
	[illegible]	[illegible]	[illegible]	[illegible]	2.30	.24	12007	....
	[illegible]	[illegible]	[illegible]	[illegible]	2.71	.25	13081	14775
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.22	.17	11861	....
	[illegible]	[illegible]	[illegible]	[illegible]	2.42	.18	12892	14535
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.11	.13	11890	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.36	.14	12720	14625
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.14	.06	11966	....
	[illegible]	[illegible]	[illegible]	[illegible]	2.32	.06	12900	14564
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.98	....	11923	....
	[illegible]	[illegible]	[illegible]	[illegible]	1.06	....	13115	14539
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.27	....	11716	....
	[illegible]	[illegible]	[illegible]	[illegible]	1.41	....	13003	14579
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	....	11875	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.28	....	12702	14624
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	....	11635	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.31	....	12553	14726
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.24	.70	11854	....
	[illegible]	[illegible]	[illegible]	[illegible]	2.42	.76	12893	14655
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.96	.55	11733	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.05	.60	12529	14540
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.95	.27	11925	....
	[illegible]	[illegible]	[illegible]	[illegible]	2.33	.29	12858	14550
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.33	.36	11909	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.76	.38	12450	14707
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.85	.36	11786	....
	[illegible]	[illegible]	[illegible]	[illegible]	4.11	.38	12414	14553
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.41	.04	12150	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.64	.04	12981	14644
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.78	.04	11745	....
	[illegible]	[illegible]	[illegible]	[illegible]	4.05	.04	12669	14334
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.43	.04	12179	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.65	.04	13012	14648
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.34	.52	11744	....
	[illegible]	[illegible]	[illegible]	[illegible]	3.52	.56	12623	14787
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.35	....	13039	....
	Dry	[illegible]	[illegible]	[illegible]	2.15	....	12934	14610
B. M.	[illegible]	[illegible]	[illegible]	[illegible]	2.92	....	11191	....
23	Dry	[illegible]	[illegible]	12.63	3.17	....	12708	12275
B. M.	[illegible]	[illegible]	[illegible]	[illegible]	1.79	....	11983	....
24	Dry	[illegible]	[illegible]	[illegible]	2.23	....	13085	14815
B. M.	5.63	[illegible]	[illegible]	[illegible]	1.23	....	12079	....
25	Dry	[illegible]	[illegible]	[illegible]	1.34	....	13220	14735
B. M.	7.78	31.81	[illegible]	5.63	1.38	....	12081	....
26	Dry	34.43	33.20	[illegible]	1.71	....	13129	14779
B. M.	5.94	32.41	[illegible]	7.66	1.28	....	12112	....
27	Dry	35.56	[illegible]	8.41	1.39	....	13303	14679
B. M.	9.07	33.00	47.54	8.18	.98	....	11923	....
28	Dry	36.30	54.51	8.88	1.06	....	13073	14597
Average	8.07	33.52	50.12	9.26	2.17	.25	11549	....
	Dry	36.43	53.48	10.05	2.34	.27	12960	14463

Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—**Continued.**

DISTRICT NO. 7—BOND CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
218	11.96	35.09	42.31	10.30	3.38	.66	10806	
	Dry	39.86	48.06	12.07	3.84	.70	12274	14240

DISTRICT NO. 7—CHRISTIAN CO., NO. 1 COAL

21	11.31	38.89	40.94	8.86	2.35	.43	11602	
	Dry	43.85	46.16	9.99	2.65	.48	13081	14717

DISTRICT NO. 7—CHRISTIAN CO., NO. 2 COAL

21	12.96	38.96	40.94	6.92	3.13	.20	11591	
	Dry	45.01	47.04	7.95	3.60	.24	13319	14691

DISTRICT NO. 7—CHRISTIAN CO., NO. 6 COAL

219	12.00	37.22	39.77	11.01	3.85	.45	10798	
	Dry	42.29	45.19	12.51	4.38	.51	12271	14455
220	13.91	36.39	39.32	10.36	4.00	.54	10682	
	Dry	42.28	45.68	12.02	4.65	.63	12410	14493
221	12.04	37.09	40.60	10.25	4.17	.22	10887	
	Dry	42.17	46.16	11.66	4.74	.26	12438	14293
222	12.10	37.64	41.00	9.17	3.71	.11	11043	
	Dry	42.83	46.73	10.43	4.22	.13	12565	13917
B. M	12.67	37.27	39.44	10.55	3.65	....	10919	
56	Dry	42.73	45.17	12.08	4.38	....	12504	14442
Average	12.54	37.12	40.03	10.27	3.89	.33	10866	
	Dry	42.46	45.79	11.74	4.47	.38	12438	14320

DISTRICT NO. 7—CLINTON CO., NO. 6 COAL

84	12.86	37.26	39.53	10.35	4.26	.58	10755	
	Dry	42.76	45.36	11.88	4.89	.66	12342	14335
85	12.39	36.88	40.68	10.05	3.52	.72	10836	
	Dry	42.10	46.43	11.47	4.02	.82	12368	14245
198	11.09	36.99	41.04	10.86	3.51	.61	10887	
	Dry	41.61	46.17	12.21	3.95	.69	12242	14450
199	11.17	34.93	43.26	10.64	3.58	.44	10920	
	Dry	39.32	48.69	11.98	4.03	.50	12294	13853
B. M.	11.71	35.21	42.63	10.44	4.06	....	11011	
46	Dry	39.88	48.29	11.82	4.59	....	12441	14363
B. M	12.53	33.43	44.20	9.83	3.96	......	10947	
47	Dry	38.15	50.55	11.23	4.52	....	12503	14501
B. M.	14.75	29.62	45.98	9.64	1.57	....	10726	
48	Dry	34.75	53.94	11.31	1.84	......	12629	14447
Average	12.35	34.90	42.47	10.25	3.49	.58	10871	
	Dry	39.79	48.49	13.12	3.97	.66	12402	14356

[illegible] *separate mines and by* [illegible] —Continued.

[illegible] COAL

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sulphur	[illegible]	B. t. u.	"Unit coal"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41 [illegible]	10549 12304	14236
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10558 12447	14408
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10964 12583	14365
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10438 12165	14338
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11069 12557	14243
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10906 12271	14209
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10540 12303	14279
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11061 12566	14139
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11012 12407	14129
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10709 12466	14191
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	10733 12508	14273
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	10536 [illegible]	14558
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	----	[illegible] 12258	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] [illegible]	[illegible]

[illegible] COAL

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sulphur	[illegible]	B. t. u.	"Unit coal"
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14421
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Table 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 7—MADISON CO., NO. 6 COAL—Concluded.

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
B. M.	12.95	34.11	41.11	11.81	4.06		10699	
35	Dry	39.19	47.23	13.57	4.66		12292	14565
B. M.	13.07	34.27	40.79	11.86	4.45		10562	
36	Dry	39.42	46.93	13.64	5.11		12115	14532
B. M.	15.09	31.00	46.49	7.42	.83		11151	
38	Dry	36.51	54.75	8.74	.98		13133	14533
B. M.	15.19	31.02	43.41	10.36	1.44		10737	
39	Dry	36.57	51.19	12.23	1.70		12567	14526
B. M.	12.69	36.50	41.45	9.35	3.72		11025	
40	Dry	41.80	47.76	10.71	4.05		12627	14466
Average	13.14	35.63	44.31	12.50	3.67	.42	10657	
	Dry	41.03	46.01	12.94	4.21	.49	12276	14471

DISTRICT NO. 7—MARION CO., NO. 6 COAL

87	10.46	36.85	41.53	11.16	4.01	.42	11174	
	Dry	41.15	46.38	12.47	4.48	.47	12480	14574
206	9.93	36.45	42.22	11.38	4.06	.31	11168	
	Dry	40.47	46.89	12.63	4.50	.34	12401	14582
207	10.41	36.71	42.31	10.56	3.27	.43	11267	
	Dry	40.98	47.22	11.79	3.65	.49	12576	14536
B. M.	10.69	36.01	41.76	11.53	3.60		11018	
52	Dry	40.32	46.78	12.89	4.03		12257	14650
Average	10.37	36.50	41.95	11.15	3.96	.29	11156	
	Dry	40.75	46.81	12.44	4.16	.32	12428	14585

DISTRICT NO. 7--MONTGOMERY CO., NO. 6 COAL

76	13.89	37.05	38.44	10.62	3.85	.94	10574	
	Dry	43.04	44.64	12.32	4.47	1.10	12280	14312
77	14.40	36.70	39.84	9.06	3.83	.49	10709	
	Dry	42.88	46.54	10.58	4.47	.57	12511	14268
194	13.19	36.30	40.62	9.68	4.07	.49	10779	
	Dry	41.81	47.03	11.15	4.69	.57	12418	14270
195	12.87	36.07	41.61	9.44	3.83	.45	10844	
	Dry	41.39	47.77	10.83	4.40	.51	12447	14348
196	12.27	36.79	40.62	10.45	4.42	.73	10799	
	Dry	41.87	46.23	11.89	5.04	.83	12298	14271
197	14.71	34.67	41.79	8.79	3.85	.42	10588	
	Dry	40.66	49.01	10.32	4.51	.49	12415	14113
B. M.	13.54	38.85	42.09	11.64	3.99		10550	
43	Dry	44.47	48.69	13.45	4.61		12185	14453
B. M.	13.17	33.64	41.34	11.83			10548	
44	Dry	38.75	47.62	13.62			12168	14394
B. M.	13.47	34.62	40.32	11.57	3.47		10558	
45	Dry	40.01	46.60	13.37	4.64		12202	14417
Average	13.50	34.96	40.74	10.34	3.91	.58	10661	
	Dry	41.65	47.12	11.94	4.60	.67	12325	14316

TABLE [illegible] *analyses and heat values for separate mines and by counties grouped according to districts*—**Continued.**

DISTRICT NO. 7 MOULTRIE CO., NO. 6 COAL

[illegible]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	11.37	4.01	.57	11878	------
	Dry	[illegible]	45.41	12.56	4.31	.61	12738	[illegible]

DISTRICT NO. 7 PERRY CO., NO. 6 COAL

[illegible]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.70	[illegible]	[illegible]	---
	Dry	[illegible]	[illegible]	13.30	4.10	.95	12150	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.80	.27	11207	---
	Dry	[illegible]	[illegible]	[illegible]	3.20	.31	12901	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.56	11060	-----
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	.63	12420	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.48	[illegible]	-----
	Dry	[illegible]	[illegible]	[illegible]	3.61	.52	12446	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.86	10763	-----
	Dry	[illegible]	[illegible]	[illegible]	4.24	.95	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.41	11139	-----
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	.45	12252	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.52	11290	-----
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	.56	12271	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.56	[illegible]	---
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DISTRICT NO. [illegible] RANDOLPH CO., NO. [illegible] COAL

[illegible]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	--
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12214	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2131	[illegible]
316	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DISTRICT [illegible] COAL

[illegible]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO₂	B. t. u.	Unit coal
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	Dry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts*—Continued.

DISTRICT NO. 7—SHELBY CO., NO. 5 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
217	10.74	36.59	41.48	10.84	3.70	.52	11050	.....
	Dry	41.15	46.64	12.20	4.16	.59	12426	14568

DISTRICT NO. 7—ST. CLAIR CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
78	11.75	38.71	38.12	11.43	3.63	.80	10874	.....
	Dry	43.86	43.19	12.95	4.11	.91	12322	14466
79	11.31	39.77	38.92	10.00	3.94	.63	11143	..
	Dry	44.84	43.89	11.27	4.44	.71	12564	14468
80	10.04	39.33	39.09	11.54	3.91	.78	11045	......
	Dry	43.72	43.45	12.83	4.35	.87	12278	14398
81	11.23	40.36	38.31	10.10	4.03	.54	11126	.....
	Dry	45.47	43.17	11.39	4.54	.61	12533	14444
82	11.94	39.72	37.53	10.81	4.46	.39	10949	..
	Dry	45.10	42.62	12.27	5.07	.45	12434	14510
200	13.74	31.44	43.54	11.24	1.79	.69	10574	..
	Dry	36.47	50.49	13.04	2.08	.79	12262	14341
201	11.66	37.78	40.80	10.09	3.69	.39	11087	....
	Dry	42.38	46.19	11.42	4.18	.44	12550	14537
202	11.09	37.37	39.59	11.93	4.62	.50	10864	..
	Dry	42.04	44.53	13.42	5.19	.56	12220	14473
203	12.26	39.93	39.32	10.39	4.32	.49	11167	
	Dry	44.63	43.86	11.60	4.97	.55	12456	14401
204	11.52	37.20	41.67	9.61	2.82	.10	11155	
	Dry	42.05	47.09	10.86	3.19	.10	12607	14394
205	9.67	37.28	41.22	11.82	3.30	.55	11044	
	Dry	41.27	45.64	13.08	3.66	.61	12227	14357
B. M. 49	13.55	34.52	42.06	10.76	3.33	....	10625	
	Dry	38.90	48.66	12.44	3.86	....	12320	14419
B. M. 50	10.75	39.66	37.99	14.00	4.09	......	10482	
	Dry	41.71	42.55	15.74	4.58	.....	11750	14607
B. M. 51	10.78	39.18	38.96	11.08	4.11	.	11069	.
	Dry	43.89	43.67	12.43	4.61	....	12405	14678
Average	11.52	38.01	39.79	11.05	3.71	.53	10918	.
	Dry	42.59	44.92	12.48	4.20	.60	12352	14463

DISTRICT NO. 7—WASHINGTON CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
86	11.13	38.20	39.39	11.28	3.91	.50	10964	...
	Dry	42.98	44.32	12.70	4.40	.56	12337	14448
226	9.42	38.65	39.71	12.21	4.30	.52	10958	.....
	Dry	42.68	43.84	13.47	4.75	.57	12098	14419
Average	10.27	38.42	39.55	11.74	4.10	.51	10961	....
	Dry	42.83	44.08	13.08	4.57	.56	12217	14483

TABLE 3.—*Average analyses and heat values for separate mines and by counties—grouped according to districts.*—Concluded.

DISTRICT NO. 8—VERMILION CO., NO. 6 COAL

Index number	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
91	14.44	35.04	40.99	9.53	2.37	.66	10982	------------
	Dry	40.95	47.91	11.14	2.77	.77	12836	14697
92	15.59	33.47	40.16	10.78	2.33	.89	10508	------------
	Dry	39.65	47.58	12.77	2.76	1.06	12449	14536
93	15.19	34.95	41.55	8.31	2.04	.65	10961	------------
	Dry	41.21	48.99	9.80	2.41	.77	12925	14533
95	12.59	40.16	38.53	8.72	3.49	.80	11228	------------
	Dry	45.94	44.08	9.98	3.99	.92	12845	14532
212	14.23	34.00	42.66	9.10	2.30	.77	11043	------------
	Dry	39.60	49.86	10.53	2.66	.90	12873	14616
B. M. 53	16.16	34.09	39.19	10.56	1.74	----------	10433	------------
	Dry	40.66	46.75	12.59	2.08	----------	12443	14472
B. M. 54	15.62	35.59	39.97	8.82	1.68	----------	10845	------------
	Dry	42.18	47.37	10.45	1.99	----------	12852	14554
Average	14.83	35.72	40.43	9.40	2.27	.75	10857	------------
	Dry	41.45	47.50	11.03	2.66	.88	12946	14562

DISTRICT NO. 8—VERMILION CO., NO. 7 COAL

94	12.69	38.78	38.89	9.64	3.34	.52	11221	------------
	Dry	44.42	44.54	11.04	3.83	.59	12852	14725
97	13.18	37.85	38.65	10.32	2.54	.60	11080	------------
	Dry	43.59	44.52	11.89	2.92	.69	12762	14754
211	13.63	37.23	39.53	9.60	7.13	----------	11030	------------
	Dry	43.13	45.73	11.13	8.33	----------	12803	14671
Average	13.16	37.95	39.02	9.85	4.33	.56	11110	------------
	Dry	39.02	44.93	11.35	5.02	.64	12805	14716

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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*

Cooperative Mining Series
BULLETIN 28

PRELIMINARY REPORT ON COAL STRIPPING POSSIBILITIES IN ILLINOIS

BY
HAROLD E. CULVER

ILLINOIS MINING INVESTIGATIONS

Prepared under a cooperative agreement between the Illinois State Geological Survey Division, the Engineering Experiment Station of the University of Illinois and the U. S. Bureau of Mines

AUG. 26th 1818

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
1925

The Forty-seventh General Assembly of the State of Illinois, with a view of conserving the lives of the mine workers and the mineral resources of the State, authorized an investigation of the coal resources and mining practices of Illinois by the Department of Mining Engineering of the University of Illinois and the State Geological Survey Division in cooperation with the United States Bureau of Mines. A cooperative agreement was approved by the Secretary of the Interior and by representatives of the State of Illinois.

The direction of this investigation is vested in the Director of the United States Bureau of Mines, the Chief of the State Geological Survey Division, and the Director, Engineering Experiment Station, University of Illinois, who jointly determined the methods to be employed in the conduct of the work and exercise general editorial supervision over the publication of the results, but each party to the agreement directs the work of its agents in carrying on the investigation thus mutually agreed on.

The reports of the investigation are issued in the form of bulletins, either by the State Geological Survey Division, the Engineering Experiment Station, University of Illinois, or the United States Bureau of Mines. For copies of the bulletins issued by the State Geological Survey Division, address State Geological Survey Division, Urbana, Illinois; for those issued by the Engineering Station, address Engineering Station, University of Illinois, Urbana, Illinois; and for those issued by the U. S. Bureau of Mines, address Director, U. S. Bureau of Mines, Washington, D. C. (See list at end of book.)

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Committee of the Board of Natural Resources and Conservation

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KENDRIC C. BABCOCK
Representing the President of the University of Illinois

EDSON S. BASTIN
Geologist

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A PRELIMINARY REPORT ON COAL STRIPPING POSSIBILITIES IN ILLINOIS

By Harold E. Culver

INTRODUCTION

General Statement

There has been an increased interest the past year in the stripping method of mining coal in Illinois. The depression in the coal industry in this State, resulting from higher production costs than in some other states, has stimulated operators to turn to this less expensive method of mining. The present compilation of data has been made in response to many requests for information which will aid in the search for strip coal land. This brief and generalized statement of all information now available will serve to show what areas of the State are likely to reward careful prospecting, and at the same time indicate those portions in which there is little likelihood of any commercially important deposits being found. By implication, furthermore, the relative importance of stripping in the coal industry of the State is suggested.

The interest of the public in the quality of coal purchased has emphasized the importance of the relative heating value of strip coal and deep mine coal. For several reasons, chief of which were the extreme shallowness of coal stripped for the market and the lack of care in preparation before present methods were in use, coal obtained by stripping has had a reputation for being wet, dirty, "sooty", high in ash content and low in heating value. With the development of larger stripping machinery and improvements in methods of operation, those features which produced a prejudice against strip coal have been largely removed, and the buying public is finding that coal so obtained is wholly adequate and satisfactory.

Early Coal Stripping in Illinois

As early as 1866, a strip mine was opened on Grape Creek in Vermilion County, and about nine years later another pit was in operation in the Danville bed in the same county. In the meantime, stripping of the Rock Island coal was carried on along Rock River in Henry County. The procedure in all these cases was very simple as no specially designed machinery was used. The surface covering was loosened with a plow and removed with a scraper, and the coal was mined entirely by hand.

A little later, operations were begun in the Mission field in the Danville region. Coal was uncovered by use of a modified dredge, but it was not until about 1890 that any coal was mined and loaded mechanically. Great difficulty was encountered in handling the surface material economically, and modification of the early types of machines appeared in rapid succession. After many failures and moderate successes, the essential features of a successful operation were worked out, and since then the development has been one mainly of dimension. Thinner coal beds and heavier overburden have been successively undertaken, until at the present time coals are being stripped at a profit which a few years ago would have been considered unavailable on any system of mining.

PRESENT EXTENT OF COAL STRIPPING IN ILLINOIS

In spite of the large number of attempts at strip mining that have been recorded in this State, at no time have there been many operations carried on simultaneously. In recent years, the number has somewhat increased, and the latest report of the Department of Mines and Minerals[1] lists a total of eighteen pits.

Table 1 shows that stripping was confined to six counties: Fulton, Jackson, Perry, Saline, Vermilion, and Williamson. The total tonnage so mined, 1,503,541 tons, was only 217,373 tons more than was produced in the same period by a single deep mine in the State. Stripping is as yet a relatively unimportant factor in the coal industry of the State.

The restriction, prior to 1924, of these operations to three coal beds in as many counties is readily understood, when it is remembered that throughout the experimental stage it was necessary that the trials be made where conditions were fairly well known. This was essential not only from the standpoint of operation, but also from that of marketing. With increased stability of the stripping business has come a demand for increased opportunity for stripping, which means the search for and development of new territory, and involves new coal beds as well as extended markets.

ACKNOWLEDGMENTS

The preparation of material for this report has been materially aided by the uniformly able and courteous assistance given by the operators of strip pits all over the State. In compiling available data, the author has drawn freely upon earlier published work, and has had the benefit of hearty cooperation of his colleagues on the Survey staff whose field work has involved some study of the Pennsylvanian beds. The author gratefully acknowledges the competent work of his assistant, Paul T. Post, in gathering information on the present operations.

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[1] Annual coal report of Illinois: Dept. of Mines and Minerals, p. 75. 1924.

TABLE 1.—*Illinois strip mines producing during fiscal year 1293-24*

	Company	County	Production
			Tons
1	*Tiger Coal Mining Company	Fulton	3,525
2	*United Electric Coal Co., No. 9	Fulton	51,950
3	*Buckheart Coal Company	Fulton	5,276
4	*Black Servant Coal Company	Jackson	171,845
5	Scott-Smith Coal Company	Perry	112,100
6	**Gayle Coal Company	Perry	....
7	*Harrisburg Coal Mining Co.	Saline	216,978
8	Yankee Branch Coal Company	Vermilion	38,045
9	Chicago Collieries Company	Vermilion	163,303
10	I. and I. Coal Company	Vermilion	3,800
11	United Electric Coal Co., No. 1	Vermilion	205,487
12	United Electric Coal Co., No. 4	Vermilion	130,297
13	United Electric Coal Co., No. 5	Vermilion	121,896
14	*Coal Belt Coal Company	Williamson	15,366
15	Mammoth Coal Company	Williamson	29,271
16	*Prosperity Coal Co., No. 1	Williamson	3,698
17	*Prosperity Coal Co., No. 2	Williamson	5,704
18	*Quaker Mining Company, No. 1	Williamson	105,000
19	*Quaker Mining Company, Fuel mine	Williamson	120,000
20	**Pyramid Coal Company	Williamson	....
	Total strip coal production	....	1,503,541

* Not producing prior to June 30, 1923.
** Not producing prior to June 30, 1924.

IMPORTANT FEATURES OF STRIP COAL LAND

In estimating the value of a given area for stripping purposes, it is necessary to consider several factors other than the presence of the bed of coal. The more important of these features are noted below, but it should be recognized that none of them can be considered separately, since in actual operations they interact. Thus, exceptionally favorable features of one sort offset unfavorable features of another, and alter the otherwise standard specifications.

Thickness and Quality of the Coal

No absolute figure for a minimum thickness of the coal bed which may be profitably stripped can be given, since the quality of the coal, the impurities in the bed, and the amount of cover, as well as other features are important factors. A commonly accepted minimum is 48 inches for a commercial operation, but other factors may considerably reduce this in certain cases. It should not be assumed, however, that the coal will necessarily be thicker farther under cover than it appears to be at the outcrop. A safe rule is to test thoroughly by drill, auger or test pit, so that the average thickness of the bed will be known. As to quality, no definite limits can be set, other than the demands of the prospective market. The cost of production in a given instance may be so low as to offset the inferior rank of a given coal, and thus make operation commercially practicable. It is best to ascertain the actual quality of the coal by standard methods.

Thickness and Character of Overburden

The mere figure of thickness of overburden is not adequate for accurate estimation of the value of a given tract, but the thickness should nevertheless be carefully measured. For any given field, where quality of coal and market conditions are established, there is usually a fairly definite ratio of thickness of coal to thickness of cover, beyond which it is unsafe to venture. In some areas, this ratio is as low as 1 to 3. Elsewhere, it is considered practicable to attempt 1 to 12. It is clear that the character of the overburden is just as important as the thickness and that the matter is complicated by several factors. Even though soft, unconsolidated material is most easily removed, it frequently happens that coal of better grade is found beneath more resistant strata, the difference in market value of the coal more than offsetting the increased cost of stripping. Again, if the thickness of cover is great, the loose material may slump from the spoil-bank and have to be rehandled at least once, thus greatly increasing the cost.

In early stripping operations, it was considered that the presence of hard beds such as massive sandy shale, black "slate", sandstone, and limestone, precluded the possibility of successful stripping. More recent work has demonstrated that the shale and "slate" do not seriously interfere with operations, and in places, even a 5-foot bed of massive limestone has been handled satisfactorily after shooting. In this connection, it may be noted that the presence of 10 or 12 feet of softer material beneath a hard limestone stratum greatly facilitates its removal, so that 5 feet of limestone at a sufficient interval above the coal is easier to remove than 2 feet of limestone capping the coal bed.

In Illinois, the large and increasing demand for agricultural limestone has led to a consideration of the crushing of the limestone occurring over coal in some strip pits. In most instances, the limestone is entirely suitable for agricultural purposes, and since it must be handled anyway, the operators would do well to consider seriously the utilization of this by-product of coal stripping. At least one pit organization has arranged to market the stone thus obtained.

Percentage Recovered by Stripping

Given the size of the tract from which cover can be removed profitably and the thickness of the bed of coal, the calculation of the actual amount of coal in the tract can easily be made, as an acre-foot of coal in the ground weighs about 1,770 tons. This figure does not, however, give the amount of coal that will be produced in the stripping for there are many factors to interfere with complete recovery. A loss of only five per cent is obtainable under exceptionally favorable conditions, but 90 per cent recovery is a safer factor for the calculation of reserves.

Transportation and Market

For a stripping operation of any size, the market situation must be fairly well canvassed with respect to a reasonably continuous demand for coal of the rank which can be produced. The matter of transportation also becomes of added importance. For small operations, the market situation can be estimated readily, since the production will be disposed of to domestic consumers. Transportation in such instances is largely outside the problem, as most of the coal is sold at the tipple.

For moderate operations, team or truck service must be planned, with highways suited to such heavy traffic in any weather. For larger operations, proximity to an established public carrier is important. A given tract might be commercially valuable if close to a freight line, and be useless ten miles away because of the increase in cost of production resulting from the demand for greater power, larger equipment, and more labor.

POSSIBLE STRIP COAL AREAS IN ILLINOIS

General Statement

Because so large a part of the enormous coal reserves of the State are readily accessible to underground mining, it might be expected that

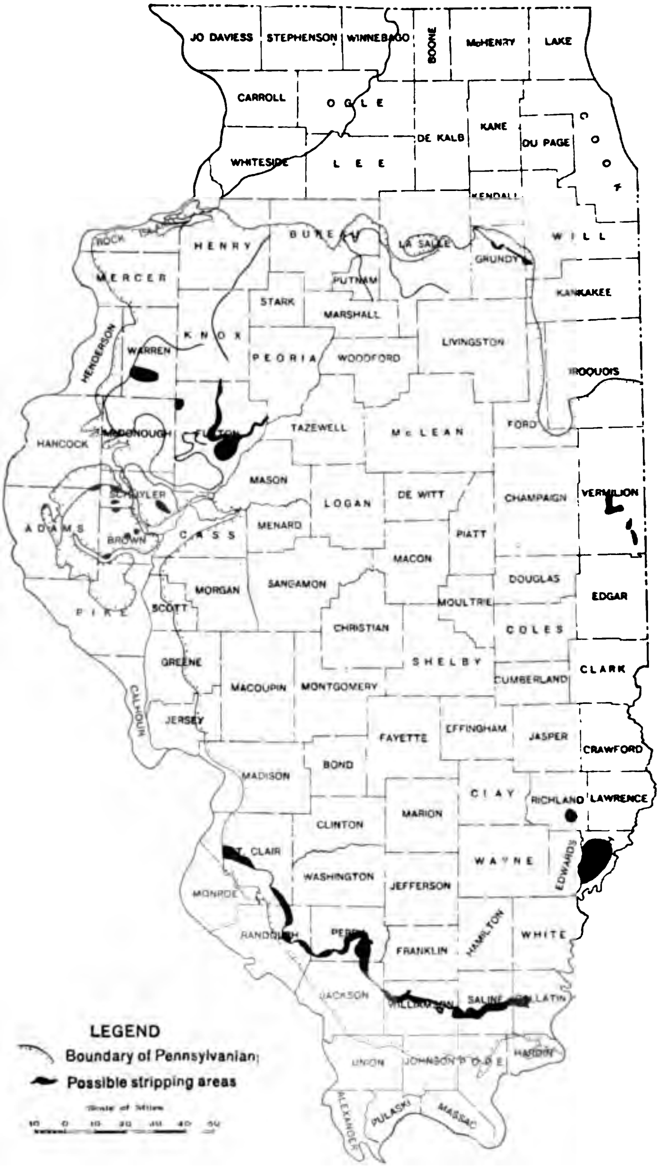

FIG. 1. Map of Illinois showing locations of possible stripping areas. The solid lines within the boundary of the Pennsylvanian system represent the line of outcrop of the several coal beds.

strip mining would be practicable in most of the counties which are underlain by workable coal beds. On the contrary, only a small fraction of the total coal area is open to stripping, and this part does not contain its proportionate fraction of the total reserves, because of the concentration of the larger reserves in the deeper parts of the field.

GEOLOGY OF THE ILLINOIS COAL FIELD

GENERAL STRUCTURE OF THE PENNSYLVANIAN SYSTEM

The great mass of rocks comprising the Pennsylvanian system fills a very broad and shallow depression south of the latitude of Rock Island, Rock Island County (fig. 1). Although the upper surface of the Pennsylvanian rocks is nearly flat, the lower surface slopes from the margin toward the deepest part of the basin. This gives a plano-convex lens shape to the system as a whole, with the greatest thickness of the beds where the basin is deepest. This deepest part is not situated in the center of the field, but is well to the southeast in Wayne County, making the basin unsymmetrical. Folding may have altered the angle of slope in some places, but in general, the beds show the low inclination acquired during the period of deposition and later consolidation. The ultimate effect has been to produce belts parallel to the margin of the field in which the gently inclined beds of coal are so lightly covered as to be available for stripping. The outer limit of these belts is indicated by the line of outcrop of the several coal beds (fig. 1). The width of the belts is obviously dependent upon the angle of slope of the strata, wider where the angle is low and narrower where it is high.

VERTICAL RANGE OF THE COAL BEDS

Neither the uppermost nor the lowermost portions of the Pennsylvanian in this State include the commercially important beds of coal. The thicker and more extensive beds are restricted to a 500-foot section approximately in the middle of the Pennsylvanian system. For this reason, the width of the marginal belts mentioned above is greatly restricted, and on the outer side of the belts, as well as on the side toward the interior of the basin, there are extensive areas in which stripping will not be important because of the absence of suitable coal beds. As the most favorable site for stripping is along the outer edge of beds now worked by underground methods, the introduction of open pit mining does not necessarily involve the utilization of any beds not now exploited. It will, however, serve to increase the total production of coal from these beds by extraction from the portions which are too shallow for deep mining. The inner limit of the stripping belt practically coincides with the outer limit of deep mining. In a general way, the areas available for strip mining will be found in a zone marginal to the present producing fields.

COAL BEDS ABOVE OR BELOW THE MIDDLE SECTION

In addition to the main producing districts of the State, there are numerous small areas which are known to be underlain by thin coal at shallow depths. Although most of these areas are small, the total acreage involved is appreciable. Occurrences of such beds in the lower part of the Pennsylvanian system are known, for example, in Saline County, south of the line of outcrop of the Harrisburg coal, the main producing bed of the district. In the upper part of the Pennsylvanian also are several thin coals, which in general are found in the interior of the field, as in Effingham and Crawford counties.

Where known to lie at shallow depths, these beds are mainly too thin to be valuable, so that no great importance may be attached to them on the basis of present data. As most coal testing has been confined to the immediate vicinity of the producing mines, it appears probable that an equal amount of drilling in these areas of shallow thin coal will reveal the presence of thicker portions not now known.

EROSION ALONG STREAM VALLEYS

Many Illinois streams flow through wide bottom valleys, somewhat below the general level of the surrounding region. Where such drainage lines cross areas underlain by workable coals, the overburden has been removed to a greater or less extent. The maximum depth of excavation is more than 100 feet in places, but along most streams it is less. The removal of even 20 feet might bring a deeply buried coal bed within the range of stripping operations. Such conditions are known in the vicinity of many drift and slope mines in which part of the workings have been abandoned on account of poor roof beneath drainage lines.

Much of the early stripping in Illinois was done in areas of this type, as in northern Henry County, where erosion by Rock River has reduced the very thick cover to less than 10 feet, so that the Rock Island coal could be stripped cheaply by team and hand scraper. In the Carterville field of Williamson County, and particularly in the Danville field of Vermilion County, operators have been quick to take advantage of the partial elimination of overburden in stream valleys. In places the operations have been continued to an extent that demanded a shifting of positions of stream channels. No careful estimate has been made of the acreage which has been added in this way to the areas available for stripping. However important in the location of a single strip pit, it is clear that this factor is of minor importance in affecting the production of the field as a whole.

AREAS OF POCKET COAL

Outside the margin of the extensive swamp areas which were the site of deposition of the more widespread coal beds of the Illinois basin, there appear to have been many similar but smaller depressions in which coal-forming matter accumulated. This marginal deposition gave rise to scores of disconnected pockets of coal of variable thickness and shape. Because of the conditions under which they were laid down, these beds do not show uniform composition but are as variable in their content of impurities as in their shape. The present western edge of the Illinois field coincides roughly with this old marginal zone, and hence this region is characterized by coals that are irregular both in extent and composition. It is to be expected, therefore, that in much of the large area in which coal is known to be present at shallow depth, it will be found to be too thin or too impure to be commercially valuable.

This situation is especially well illustrated in that part of the coal basin lying west of the Illinois, but it may also be found to obtain in other parts of the State as well. On this account the available stripping area may be reduced by an unknown but appreciable amount.

GLACIAL DRIFT

The deposits of sand, gravel, and boulder clay which mantle practically all of the coal field, add greatly to the complexity of the problems of open pit mining. Perhaps the most important effect is in the addition to the amount of overburden, making unavailable some coal that otherwise could be stripped. This is especially true throughout the northern part of the field where the thickness of the surficial material is excessive, in some places reaching a maximum of 200 feet. A second effect is the concealment of bed rock relations, necessitating extensive drilling to ascertain the presence or absence of the coal, the total overburden and the amount of included bed rock.

In addition, although the drift materials are commonly unconsolidated, and hence easily removed, their occurrence in excessive thicknesses makes them difficult to handle in wet weather because of the tendency to slump from the spoilbank into the open cut.

Estimation of Available Area and Tonnage

In a consideration of the areas which are here suggested as possible strip coal lands, it should be remembered that the data on which the suggestions are based are very incomplete. No special field work has been done on which an estimate of the availability of coal land for stripping could be based, and it has therefore been necessary to make use of data gathered largely as an incidental phase of other studies. These include topographic maps, records of outcrops, well logs, mine workings, and similar material, from which both thickness of any given coal and its depth below the surface may be calculated.

On figure 1 are indicated approximately the stripping areas in the State, to show the relation of the fields to each other, and to the rest of the State. Accompanying the detailed discussion of each county is presented a larger scale map showing the position of possible strip lands in greater detail. It is clear that areas mapped as possible strip lands are those which available data indicate as worthy of test. It is to be expected that some portions of these areas will be found to contain coal or overburden of such thickness as to make commercial operations impracticable. Additional areas not now known will presumably be found as the search for strip land progresses. The boundaries of areas indicated are necessarily generalized and subject to revision as more accurate data become available. Similarly, the thickness of coal and the amount of overburden are calculated from present information, and are subject to corrections for the areas less well known. Because of these features, the estimation of tonnage available by stripping as presented in Table 2 is necessarily an approximation. The figures are included only in order to give some idea of the amount of coal for any given field. It should be noted that this calculation is based on a recovery of 100 per cent of the coal, as the variations from this figure due to local geologic conditions or methods of mining can not well be calculated in advance of actual operations.

The total available tonnage of strip coal in Illinois has been estimated to be 1,407 million tons from an area of 287 square miles. It has also been estimated that 197 square miles are underlain by strip coal 48 or more inches thick and can supply 1,137 million tons of strip coal. Of the original coal resources in Illinois—137,000 million tons, 1.02 per cent represents the estimated stripping resources.

CHEMICAL COMPOSITION OF STRIP COAL

As noted earlier in this report, strip coal has long had a reputation for its high content of impurities. It is obvious that coal exposed to weathering agencies deteriorates both in composition and appearance. The more readily volatilized constituents are lost to the air, or oxidized through the action of percolating water; the pyrite which always is present in coal beds is decomposed and the resulting iron oxide is scattered through the bed as a rusty stain which detracts materially from the appearance of the coal and which can not be removed as the unweathered pyrite could.

Coal overlain by a thin mantle of glacial drift is likely to have the character of weathered coal. The earlier stripping done in this State was of coal in just this situation, so that the marketed product was necessarily of lower grade than that from the more deeply buried portions of the bed.

TABLE 2.—*Estimate of stripping resources in Illinois*

County	Thickness	Area	Tonnage
	Inches	*Sq. mi.*	*Millions of tons*
Adams	30	2	5
Brown	24	3	6
Fulton, Springfield (No. 5) bed	48	60	272
Fulton, Colchester (No. 2) bed	30	5	14
Gallatin	72	3	20
Grundy (including Will)	30	9	25
Hancock	30	5	14
Jackson	72	8	54
Knox		(No estimate)	
Perry	72	35	238
Randolph	72	19	129
Richland	24	4	9
Saline, Herrin (No. 6) bed	36	2	6
Saline, Harrisburg (No. 5) bed	60	6	34
Schuyler	66	12	74
St. Clair	60	30	170
Vermilion, Danville (No. 7) bed	54	10	51
Vermilion, Grape Creek (No. 6) bed	72	4	27
Wabash	36	40	135
Warren	30	20	56
Williamson	72	10	68
Total		287	1407

Again, both upper and lower surfaces of the bed of coal are likely to be uneven. Unless the stripping and loading of such a bed be done with extreme care, a considerable admixture of shale, bone coal, and floor clay will probably result. Early stripping, done with inadequate equipment, resulted in the loading of much incombustible material with the coal.

TABLE 3.—*Comparative analyses of strip and deep mine coal from the same bed*[a]

As received						Dry					
Moisture	Vol. mat.	Fixed carbon	Ash	Sulphur	B. t. u.	Vol. mat.	Fixed carbon	Ash	Sulphur	B. t. u	No. of analyses
13.79	*37.62*	*39.28*	*9.31*	*3.50*	*10956*	*43.64*	*45.56*	*10.80*	*4.06*	*12708*	*Single*
14.89	35.48	40.75	8.88	3.78	10969	41.68	47.88	10.44	4.43	12887	Single
13.89	*34.87*	*36.54*	*14.70*	*5.80*	*10036*	*40.50*	*42.43*	*17.07*	*6.73*	*11656*	*Single*
16.83	34.68	39.79	8.70	3.94	10628	41.71	47.83	10.46	4.74	12778	Single
13.75	*36.59*	*37.38*	*12.28*	*2.92*	*10560*	*42.42*	*43.34*	*14.24*	*3.38*	*12243*	*Single*
14.04	36.14	39.28	10.54	3.46	10721	42.04	45.69	12.27	4.02	12472	Single
12.36	*36.69*	*40.90*	*10.05*	*3.00*	*11194*	*41.87*	*46.67*	*11.46*	*3.42*	*12733*	*Single*
12.03	36.30	39.67	12.00	3.35	10779	41.27	45.08	13.65	3.81	12254	Single
11.52	*37.20*	*41.67*	*9.61*	*2.82*	*11155*	*42.05*	*47.09*	*10.86*	*3.19*	*12607*	*Single*
11.09	37.37	39.59	11.93	4.62	10864	42.04	44.53	13.42	5.19	12220	Average of 3
6.40	*36.71*	*47.70*	*9.19*	*3.41*	*12150*	*39.22*	*50.96*	*9.82*	*3.64*	*12981*	*Single*
7.29	34.93	47.65	10.13	3.78	11745	37.68	51.39	10.93	4.08	12669	Single
6.40	*36.38*	*48.20*	*9.02*	*3.45*	*12179*	*38.87*	*51.49*	*9.64*	*3.69*	*13012*	*Single*
6.95	36.05	45.33	11.65	3.54	11744	38.75	48.73	12.51	3.81	12623	Average of 3
13.10	*37.70*	*39.80*	*9.40*	*2.80*	*11110*	*43.40*	*45.80*	*10.80*	*3.20*	*12770*	*Single*
12.20	39.53	38.38	9.89	3.76	11243	45.03	43.70	11.27	4.29	12804	Single
14.10	*37.00*	*39.30*	*9.60*	*2.90*	*11030*	*43.10*	*45.70*	*11.20*	*3.40*	*12480*	*Single*
12.76	38.84	38.31	10.09	3.91	11106	44.53	43.91	11.56	4.48	12788	Single
13.70	*37.00*	*39.50*	*9.80*	*3.20*	*11050*	*42.90*	*45.70*	*11.40*	*3.70*	*12800*	*Single*
13.53	37.39	39.57	9.51	3.20	11045	43.24	45.76	11.00	3.70	12773	Single
13.63	*37.23*	*39.53*	*9.60*	*2.96*	*11030*	*43.13*	*45.73*	*11.13*	*3.36*	*12803*	*Average of 3*
12.69	38.78	38.89	9.64	3.34	11221	44.42	44.54	11.04	3.83	12852	Average of 6

[a] Figures in italics refer to strip coal.

A thicker cover of drift means greater protection from weathering, resulting in a higher grade of coal. A hard, relatively impermeable boulder clay is obviously a better cover than one of sand and gravel of even greater thickness. Where the overburden includes bed rock, weathering is still further prevented. A stratum of well bedded shale beneath a limestone of moderate thickness makes an especially good cover, as the limestone stratum diverts much of the ground water and the shale transmits but little of the rest of the moisture to the coal.

The large size of present equipment for stripping permits the removal of a much thicker overburden than was formerly possible, and the great strength of the machines now in use allows the handling of the more resistant bed rock. Coal of excellent quality is therefore uncovered in modern pits. With greater care in cleaning the surface of the strip bed, and better control of loading shovels than was formerly possible, the loaded coal may be as clean as that from deep mines. Impurities that are present in all coal beds, such as lenses or balls of pyrite and bands of shale or bone may be as completely eliminated on the picking tables of a strip mine as those of a deep mine. From the geologic point of view, therefore, strip coal is not inherently of poorer quality than deep mine coal.

The analyses in Table 3 which represent face samples of coal, show the composition of coal from strip mines and from deep mines working the same bed. In order to conceal the identity of analyses, it has been necessary to omit the designation of the bed or of the county in which it was sampled. Each pair of analyses, however, is of the same bed, the deep mine sample being chosen from a location as near as possible to that taken from the strip mine. It must be remembered that the samples are of face coal, and hence not exactly indicative of commercial output. Depending on methods and care in mining, the loaded coal will be better or poorer in grade than the face sample. Even casual inspection of the analyses will show that the coal at the face of a strip pit is fairly comparable with that at the face in a deep mine.

COUNTY REPORTS

ADAMS COUNTY

The Adams County coal beds belong to that part of the Illinois field which has been cut off from the main basin by Crooked Creek and Illinois River (fig. 1). The whole series is relatively thin in this area, and the included coals are of comparatively little value.

A small area surrounding the southeast corner of T. 2 N., R. 8 W. lying northeast of the village of Mendon (fig. 2), is known to contain coal which might be stripped. Elsewhere in this county conditions appear to be unfavorable for commercial stripping, although there are small patches where thin coal is so lightly covered that small scale stripping may be possible.

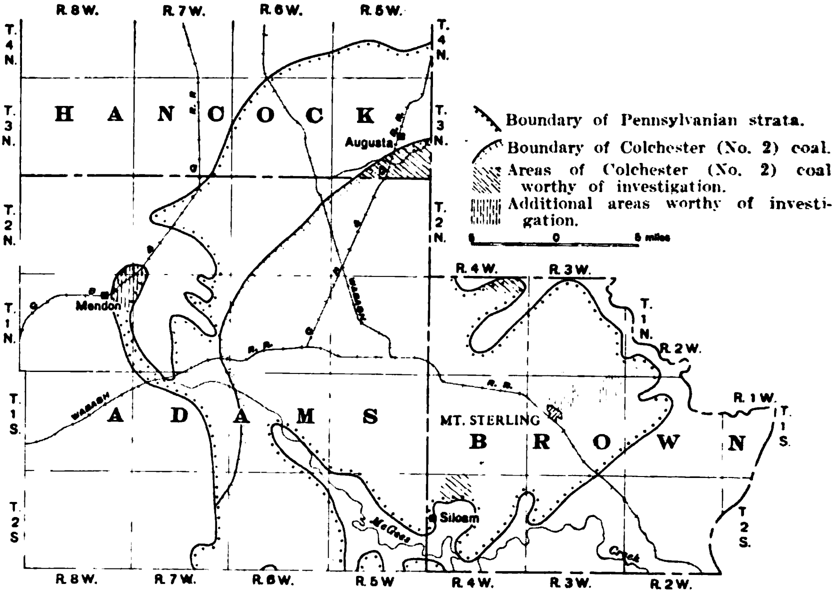

FIG. 2. Index map of Adams, Brown and Hancock counties.

The coal northeast of Mendon has an average thickness of 48 inches, but it is nearly 60 inches at its maximum. The bed is distinctly limited in extent, however, and shows the high content of impurities common to marginal deposits. A measured section shows a 2-inch bone band 8 inches from the top of the bed, and a 2-inch band of shale 28 inches above the sandstone floor.

The original shale roof material has been replaced locally by glacial drift. Over the small area observable, the cover ranges from 2 to 30 feet, and probably contains little bed rock. In sec. 36, T. 2 N., R. 8 W., a small stripping operation was producing coal in 1922, but no later reports are available.

BROWN COUNTY

The major portion of the large area of Brown County north and east of McGees Creek is probably underlain by the Colchester or No. 2 coal. Most of this region is so heavily covered however, that it is doubtful if any commercial strip land is included. In two places, one northwest of Mt. Sterling, in T. 1 N., R. 4 W., and the other north of Siloam in T. 2 S., R. 4 W. (fig. 2) local stripping has been attempted, and these points are noted on the map as worthy of investigation.

The coal in either place is about 2 feet in thickness, varying but little over wide areas, and having some impurities but no regular partings. The covering is less than 20 feet thick locally, but it is not known over how large an area such relations obtain. Where thin, the cover is largely glacial drift and the coal relatively soft and weathered. The thicker cover includes varying amounts of bed rock which is mainly sandstone and shale, but which in places includes a massive limestone. In the character of cover, this field resembles Schuyler County to the north.

Over a small area just north of Mt. Sterling, a coal stratigraphically above the Colchester (No. 2), locally called No. 5, has been mined in the past. It is near the surface, the cover along the creeks being thin but including a considerable thickness of bed rock, in part limestone. In outcrops, this coal is less than 2 feet thick and bony, and is not listed among the probable coal resources of the county.

CLAY COUNTY

Described on page 57.

EDWARDS COUNTY

Described on page 57.

EFFINGHAM COUNTY

Described on page 57.

FULTON COUNTY

Fulton County has long been recognized as containing within its boundaries some very desirable stripping areas, but it is only within the last few years that development on a commercial scale has been attempted. The large scale operations in the vicinity of Cuba will probably be followed by others. The Cuba coal appears to be present throughout a considerable area under approximately the same conditions of cover, thickness of coal and relation to drainage. Part or all of each of the following townships seem to merit some exploratory work:

T. 5 N., Rs. 3 and 4 E.	T. 7 N., R. 3 E.
T. 6 N., Rs. 2, 3, 4, and 5 E.	T. 8 N., R. 3 E.

The coal is the Springfield (No. 5) bed, which has long been worked underground in this county, and even more extensively in the counties east and south. The character and general relations of the coal are already well known,[1, 2] leaving only the matter of thickness of bed and thickness and character of overburden to be determined in exploratory work.

The thickness of the coal is remarkably uniform, ranging from 48 to 60 inches wherever measured. The characteristic feature of this bed, namely, the presence of clay-slips or "horsebacks" is of importance in any projected operation. The slips range from a few inches to several feet in width, and are very irregular in distribution, some areas being quite free from them, others, having as many as twelve slips in a distance of 15 feet.

The overburden is extremely variable both in thickness and in character. Throughout the areas indicated in figure 3, the cover is believed to be less than 65 feet, which may be the limit of practicable operation for the thickness of coal uncovered. The size of tracts in which the cover is of uniform thickness depends more on the surface configuration than on any other factor. Where undisturbed by erosion, the common sequence of strata over the No. 5 coal is 2 feet of black laminated shale composing the roof, overlain by limestone less than 1 foot thick, over which lies shale up to 25 feet in thickness with a variable amount of till over the whole. This group of beds is common in the eastern part of the county, but is not uniformly present over the coal farther to the west and south where the interval between the No. 5 and No. 6 coals is locally as small as 8 feet. At points where the interval is small, the shale is commonly replaced by sandstone. In places, the sandstone cuts out the limestone cap of the No. 5 coal. In this connection, it is of importance to note that where the sandstone is of appreciable thickness, the coal bed is essentially free from clay-slips. In such areas the prospective operator of a strip pit

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[1] Savage, T. E., Geology and mineral resources of the Avon and Canton quadrangles: Ill. State Geol. Survey Bull. 43, p. 209, 1922.

[2] Cady, G. H., Coal resources of District IV: Ill. Min. Inv. Bull. 26, 1921.

must consider the removal of at least 25 feet of hard sandstone, in order to reach a coal that will show few interruptions of the "horseback" type.

The Springfield coal has been stripped in a small way for many years in places where the cover is unusually thin. Within the past three years, however, extensive drilling in the Cuba area has shown

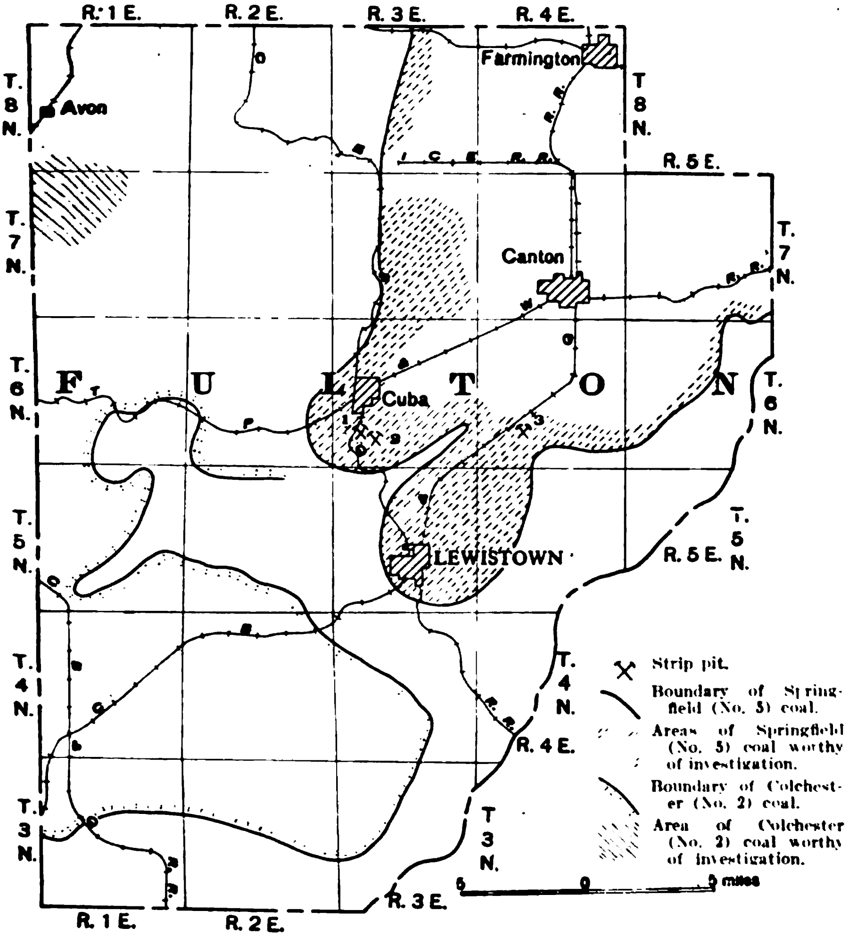

R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
T. 8 N.
T. 7 N.
T. 6 N.
T. 5 N.
T. 4 N.
T. 3 N.
Avon
Farmington
Canton
Cuba
LEWISTOWN
F U L T O N
Strip pit.
Boundary of Springfield (No. 5) coal.
Areas of Springfield (No. 5) coal worthy of investigation.
Boundary of Colchester (No. 2) coal.
Area of Colchester (No. 2) coal worthy of investigation.
5 0 5 miles

FIG. 3. Index map of Fulton County. Figures accompanying strip pit symbols refer to mines listed in Table 1.

the feasibility of pits on commercial scale, and two such pits are being operated in secs. 28 and 29, T. 6 N., R. 3 E. at the present time. One other pit in T. 6 N., R. 4 E. has been reported.

At the time of visit by a Survey representative, the following section of coal and overburden was exposed at the pit in sec. 28, T. 6 N., R. 3 E.:

Section exposed at pit in sec. 28, T. 6 N., R. 3 E.

	Thickness Ft.	Thickness In.
Soil and till, with boulders up to 18 inches in diameter; becomes plastic when wet	**26**	**..**
Shale, light gray, not well bedded	**..**	**4**
Limestone, medium gray, argillaceous, fossiliferous (locally nearly 2 feet thick)	**..**	**8**
Shale, very tough, dark, slaty at base	**2**	**9**
Coal	**4**	**9**
Underclay, light gray, without grit	**..**	**..**

The stripping is done by three electric shovels, two with 90-foot booms carrying 6-yard dippers and one with an 80-foot boom carrying an 8-yard dipper. The pit equipment is well shown in figure 4. In operating, the stripping shovel makes a straight cut, the loading tracks being shifted as the stripping shovel returns. The surficial material not removed by the stripping shovel is handled by a shovel gang followed by sweepers. The coal is shot with blasting powder, preparatory to being loaded out by the electric shovels having a dipper capacity of one and three-fourths yards. Haulage from the pit is accomplished by use of locomotives pulling trips of twelve 6-ton cars. A rotary 2-car dump operated by compressed air turns the loads on to a steel conveyor which takes the coal to the tipple for cleaning and sizing. Four loading booms handle the coal from tipple to railway cars.

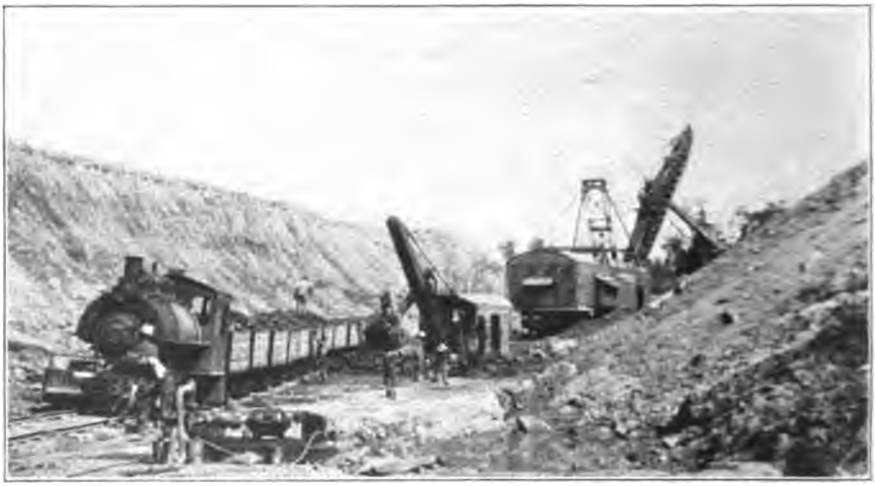


FIG. 4. Stripping operation in the Cuba field.

In addition to the areas above noted in which the Springfield (No. 5) coal lies at shallow depth, there probably are small fields in the western part of the county in which the Colchester (No. 2) coal is near enough to the surface to be stripped. One of these tracts is in the northwest quarter of T. 7 N., R. 1 E., south of Avon (fig. 3.)

In this field, the Colchester coal has an average thickness of 30 inches, varying but little from that amount over considerable areas. This bed is regularly without partings, and contains only a small amount of impurities. Its thinness obviously prevents its being considered where the overburden averages more than 30 feet in thickness, and it is probably of only local interest as a stripping coal.

The overburden is largely shale, which in places includes some thin black "slate" and nodular limestone. It seems probable that in part or all of secs. 3, 4, 5, 6, 7, 8, 17 and 18, T. 7 N., R. 1 E., the overburden does not exceed 60 feet, and that limited tracts of lesser cover will be found. Extensive drilling will be necessary to prove the presence of the coal in parts of this tract.

A similar area, somewhat larger, has been reported is Tps. 3 and 4 N., R. 1 E., but recent geologic work in this field indicates that the Colchester coal is here too deeply buried to be available for shovels.

GALLATIN COUNTY

So little is known of the coal geology of Gallatin County that it is not possible to define the stripping areas adequately. As noted in the discussion of strip land in Saline County (p. 40), there is an extension of the geologic conditions found in eastern Saline into western Gallatin (fig. 20). The outcrop lines of both the Harrisburg (No. 5) and Herrin (No. 6) coals pass through T. 9 S., R. 8 E., but their trend beneath the lowland to the east and north is not known.

In this area the Herrin coal is from 36 to 68 inches thick, as shown in drill records, and exhibits the usual parting of shale near the bottom of the bed. For detailed description of this coal, the reader is referred to the report on Williamson County.

The overburden is heavy, except just at the outcrop, so that only a narrow belt can be included in the stripping field. Immediately over the coal is thin black shale, locally slaty, and over this a limestone cap rock which may be as much as 5 feet thick and which is in places separated from the black shale by several feet of gray shale.

The Harrisburg coal in Gallatin County has essentially the same character as noted in the Saline County report. Partings of pyrite may be slightly more common in this field, and the coal on the whole less thick.

The chief difference in the overburden above the Harrisburg coal in Saline and Gallatin counties is in the absence of the limestone in the latter. This leaves only the gray and black shale with an overlying sandstone in places in the bed rock portions of the overburden. Surficial clays, here as elsewhere, cover the bed rock.

In the area tentatively mapped as worth testing for stripping possibilities, the total overburden is thought to be under 60 feet. It is probable that along stream lines, erosion has reduced this to a smaller figure and that fair sized tracts will be found to be available for stripping the Harrisburg coal.

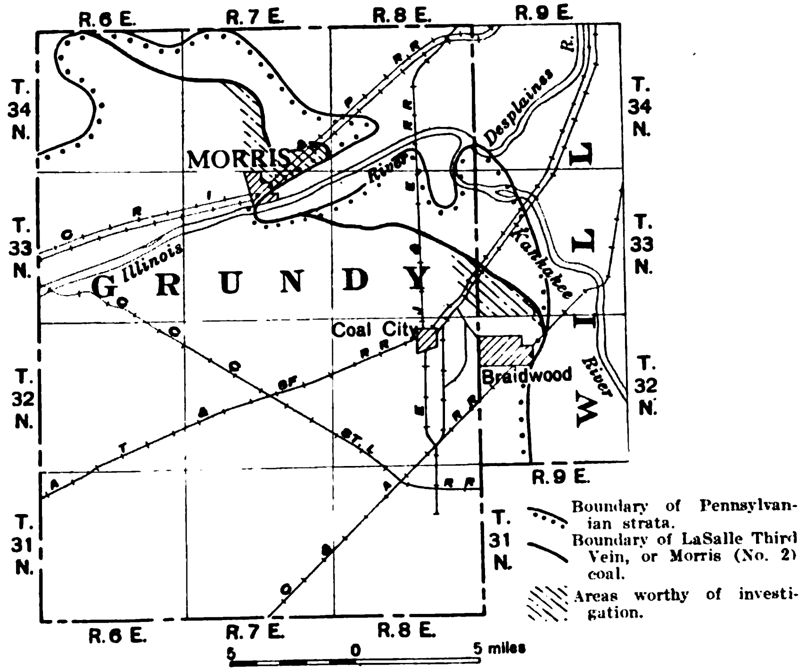


FIG. 5. Index map of Grundy and southwestern Will counties.

Grundy and Will Counties

Although more than the southern half of Grundy County is underlain by workable coal, it is only along the north margin of the field that the cover is so slight that stripping appears practicable (fig. 5). In the south central part of T. 34 N., R. 7 E., available records show 2 to 3 feet of coal at less than 60 feet below the surface. Early mining in this area has probably rendered at least half of this coal unminable, and records do not show precisely what parts have been mined out. It appears probable that west of the area mapped for investigation north of Morris, the coal is too deeply buried for stripping. Even along the boundary of the coal to the northwest, the heavier morainic covering prevents stripping. On the south side of the Kankakee in T. 33 N., Rs. 8 and 9 E., there is another tract of about 2½ square miles mostly in Grundy County, but extending across the line into western Will County in which similar conditions obtain.

In both areas, the available coal is the La Salle Third Vein or Morris coal, correlated as No. 2 of the Illinois series. This ranges from 30 to 42 inches in thickness, and is exceptionally uniform for considerable distances. The thin cover over the coal in the south tract has resulted from erosion by glacial waters passing down Kankakee Valley. Because of this fact, it is to be expected that locally the coal, as well as the heavier overburden, has been removed, a feature which should be given consideration in future prospecting. The coal is of good quality, generally free from bedded impurities and without prominent interruptions, with the possible exception above noted.

The overburden, as shown by logs, consists of the roof shale, a somewhat massive gray, slightly sandy bed, and the usual boulder till. The latter has been removed over much of the area north of Coal City and Braidwood and replaced by unconsolidated silts and sands of the glacial streams. In places, heavy gravels may be encountered. The cover is probably less than 50 feet thick in general, and some fairly large tracts will probably be found in which the cover is less than 30 feet.

HANCOCK COUNTY

Although patches of Pennsylvanian beds are found in many parts of Hancock County, the only area in which stripping possibilities appear to warrant testing lies south of Augusta in T. 3 N., R. 5 W. (fig. 2, p. 20).

In this area the Colchester (No. 2) coal, with an average thickness of 30 inches, has been worked both north and south of William Creek. The bed has no persistent parting, although the upper part is commonly harder and brighter than the lower. Over part of the field, a slightly thinner coal, known as "the cannel", underlies the Colchester at a distance varying from 2 to 8 feet. It is probable that any stripping operation opened in the Colchester coal could in places be profitably carried down to the next lower coal.

The overburden ranges from less than 10 feet to 100 feet or more in thickness. The uneven surface of the coal itself results in a cover of uneven thickness, which prevents accurate estimation of thickness in advance of testing. Where thin, the overburden is largely glacial drift, but where it is more than 15 feet, it normally includes some bed rock. Shale and sandstone in considerable thickness are reported in drill logs, and a 9-foot limestone appears in some records. On account of the thinness of the coal, it is probable that not more than 25 feet of cover could be handled profitably.

No stripping has as yet been reported from the Augusta field, although the coal has been worked from several openings, both shaft and drift.

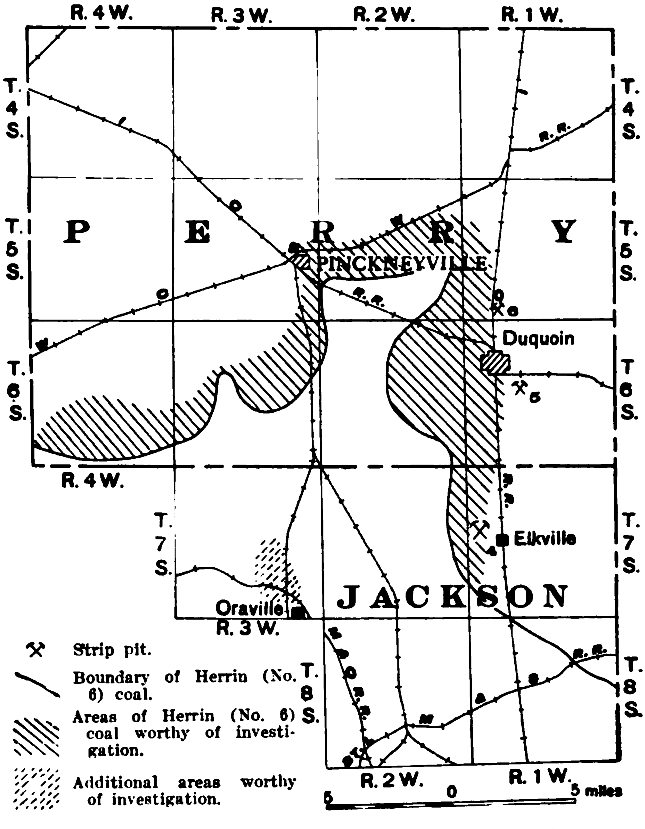


FIG. 6. Index map of Perry and Jackson counties. Figures accompanying strip pit symbols refer to mines listed in Table 1.

Near Nauvoo at the western edge of the county, a thin coal was stripped by the Mormons at an early date, but this bed appears to be of so little value that it is not included in the present estimate of stripping resources.

JACKSON COUNTY

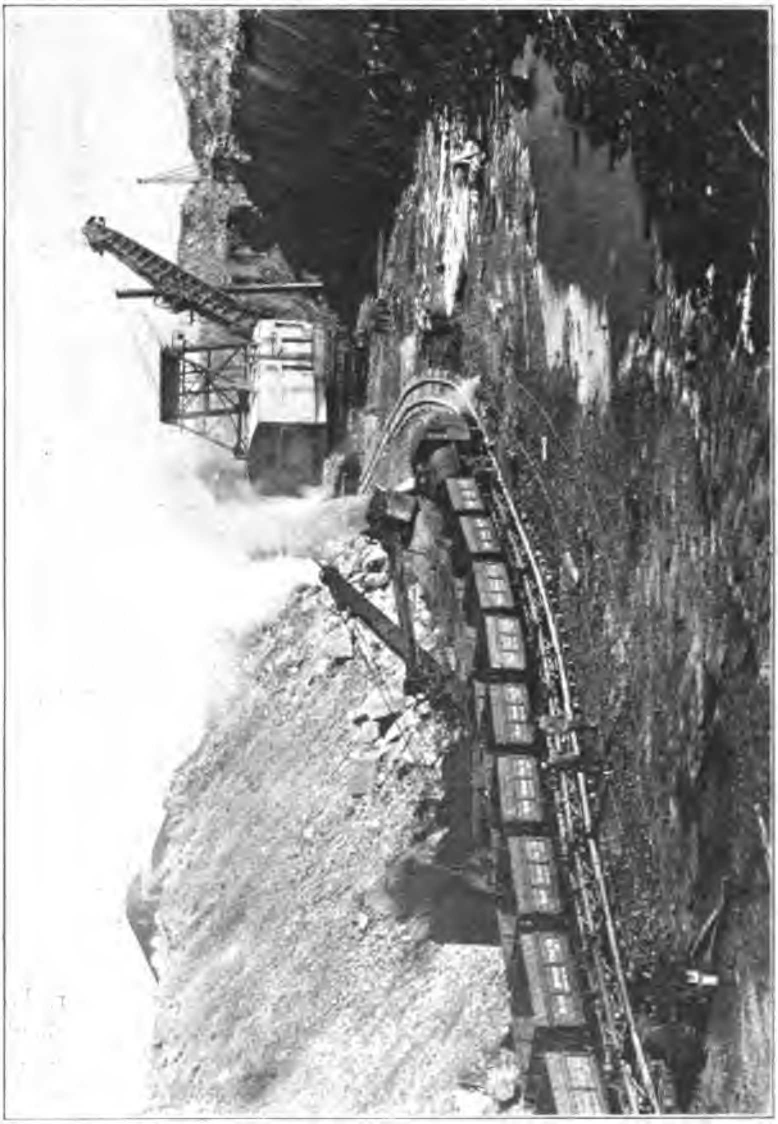
The only field in Jackson County in which stripping is known to be a possibility, is in the vicinity of Elkville in T. 7 S., Rs. 1 and 2 W. (fig. 6). Beds in this field constitute an extension of the strip lands of southeastern Perry County. A heavy cover of glacial drift prevents determination of the position of the outcrop, and hence the exact area of strip land can not be described. Because of the eastern dip of the coal on the east side of the Duquoin fold, the stripping area is limited in that direction. To the north and west, and possibly to the south, even beyond the mapped boundary for the coal, are lands well worth testing for shallow coal.

The coal in this field is the Herrin (No. 6) bed, which has been mined by underground methods throughout the area to the north and east. In this region it appears to maintain a thickness of about 84 inches, but this may be reduced nearer the outcrop. As elsewhere in southern Illinois, this bed carries the "blue band", a persistent shale parting, below the middle of the bed. Other partings of shale or pyrite are noted locally, but none are as widespread as the "blue band".

The coal is immediately overlain by shale, locally black and slaty, elsewhere gray and more massive. Above this appears the usual cap limestone, in places more than 5 feet thick, but not uniformly present. This in turn is overlain by more shale and glacial materials of varying thickness. Figure 7 shows the character of the overburden, the steep walls of uncut surficial material are seen at the right, the spoil bank showing the blocks of underlying limestone at the left. In places the coal apparently has an overburden less than 25 feet thick, but some records indicate a thickness of more than 60 feet. The prospector must consider the probability that the surface of the coal is uneven, so that, although the land surface is flat over the area indicated on the map, the variation in thickness of cover due to that feature alone may be more than 10 feet.

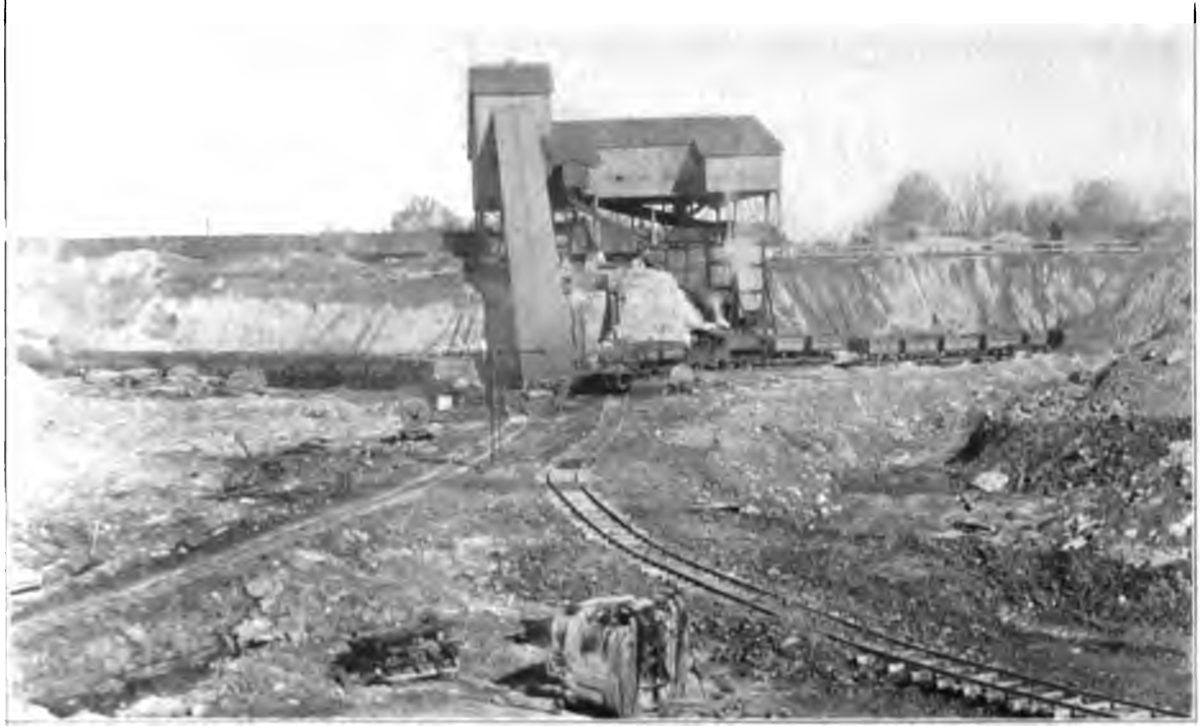
Up to the last few years, commercial stripping had not been attempted in this field, on account of the cap limestone which had been considered an insurmountable difficulty. In the pit which is now operating about a mile and a half west of Elkville, this difficulty seems to have been satisfactorily overcome, by use of extra large and sturdy equipment. Here, the stripping shovels are two in number, both electrically operated and handling 8-yard dippers. The coal is hauled from the pit over a 36-inch gage track by steam locomotives, dumped through a hopper (fig. 8) to an endless conveyor which carries it to the shaker screens where standard Illinois sizes are prepared. Picking tipples and loading booms are installed to permit the loading of clean and properly sized coal. The tipple is planned for a capacity of over 2500 tons per day.

In the southeastern part of T. 7 S., R. 3 W. near Oraville is a



Courtesy of Black Servant Coal Company.

FIG. 7. Strip pit at Elkville, T. 7 S., R. 1 W., Jackson County.



Courtesy of Black Servant Coal Company.

FIG. 8. Tipple and layout at Elkville pit, T. 7 S., R. 1 W., Jackson County.

tract of small size that may repay investigation for stripping. The coal in this field appears to lie too low to be at the horizon of the Herrin (No. 6) bed, and too high for that of the Murphysboro (No. 2) bed. It may be a local development of the No. 5 coal, such as occurs south of the Sparta field in Randolph County. The coal has been mined by drift and shallow shafts for many years, but it is possible that testing will show some valuable tracts. The bed ranges from 72 to 90 inches in thickness, and appears to be of excellent quality, although no analyses of standard type are available. Little is known of the character of the overburden, but it appears to include some sandstone, although it may be mainly shale. The known thickness of cover is less than 60 feet in places, but since so little is known of the lay of the bed, it is impossible to gage the size or value of the tract. This bed is not included in the estimate for the county.

JEFFERSON COUNTY

Described on page 57.

JOHNSON COUNTY

Described on page 58.

KNOX COUNTY

In spite of the fact that four different seams of coal have been worked by underground methods in Knox County, it is not evident from available data that there are any considerable areas of strip coal within its limits. Two regions might be mentioned as being perhaps worthy of some exploratory work (fig. 9).

The first of these lies along the outcrop of the Herrin (No. 6) coal, in the vicinity of Oneida and Wataga. The overburden may be light enough, especially along drainage lines, to permit shovel work in uncovering the coal, which ranges from 30 to 60 inches in thickness. The immediate roof is shale overlain by massive limestone 3 to 4 feet in thickness. To the southeast near Dahinda, T. 11 N., R. 3 E., one drill record reports a 33-inch coal at a depth of only 30 feet. It is improbable that so little cover is found over any extensive tracts in this part of the county.

The other possibly favorable area is in the southwest part of the county between Knoxville and St. Augustine, underlain by the Colchester (No. 2) coal and locally by the Rock Island (No. 1) coal. Along stream flats and to some extent in the upland areas, coal 24 to 30 inches thick may be present at depths less than 40 feet. So few records of drilling are available, however, that it is not possible to say to what extent the coal is present. No estimate of tonnage available for stripping in Knox County has been made.

MARION COUNTY

Described on page 57.

PERRY COUNTY

Including within its boundaries somewhat more than 30 miles of the line of outcrop of the Herrin (No. 6) coal, Perry County appears to hold some of the most promising areas for stripping in the State (fig. 6). Although not determined with great accuracy, the boundary of this important bed is mapped to lie within the following townships: T. 5 S., Rs. 1, 2, and 3 W.; T. 6 S., Rs. 1, 2, 3, and 4 W. The rather extensive field for exploration results from the presence of the Duquoin fold, which trends approximately north and south through the eastern part of the county near Duquoin, and brings the Herrin coal near the surface all along the crest. The effect of this structure is better understood when it is realized that the coal which practically outcrops at Duquoin lies 400 feet beneath the surface three miles to the east.

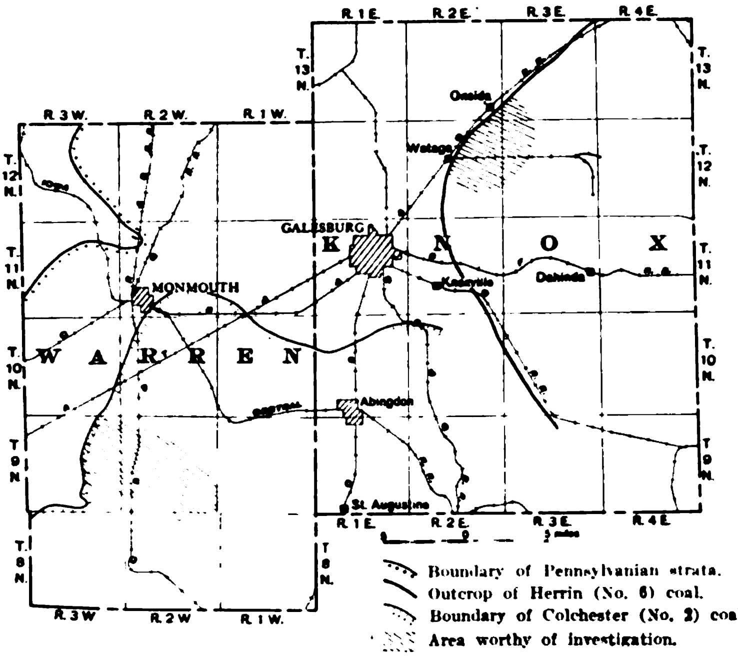


FIG. 9. Index map of Warren and Knox counties.

probably less than 60 feet thick. Because of the small amount of information available, it is probable that local variations from this maximum will be found. It is not unlikely that considerable areas of relatively thin cover may be proved up.

Immediately over the coal is shale, commonly black and sheeted, but in places gray and slightly sandy. This averages about 3 feet thick, but is reported to reach a thickness of 23 feet in places. Over the shale is the cap limestone 2 to 5 feet thick overlain by shale and thin limestone beds. Figure 10 shows the character of the overburden where it includes about equal amounts of loose and bed rock material.

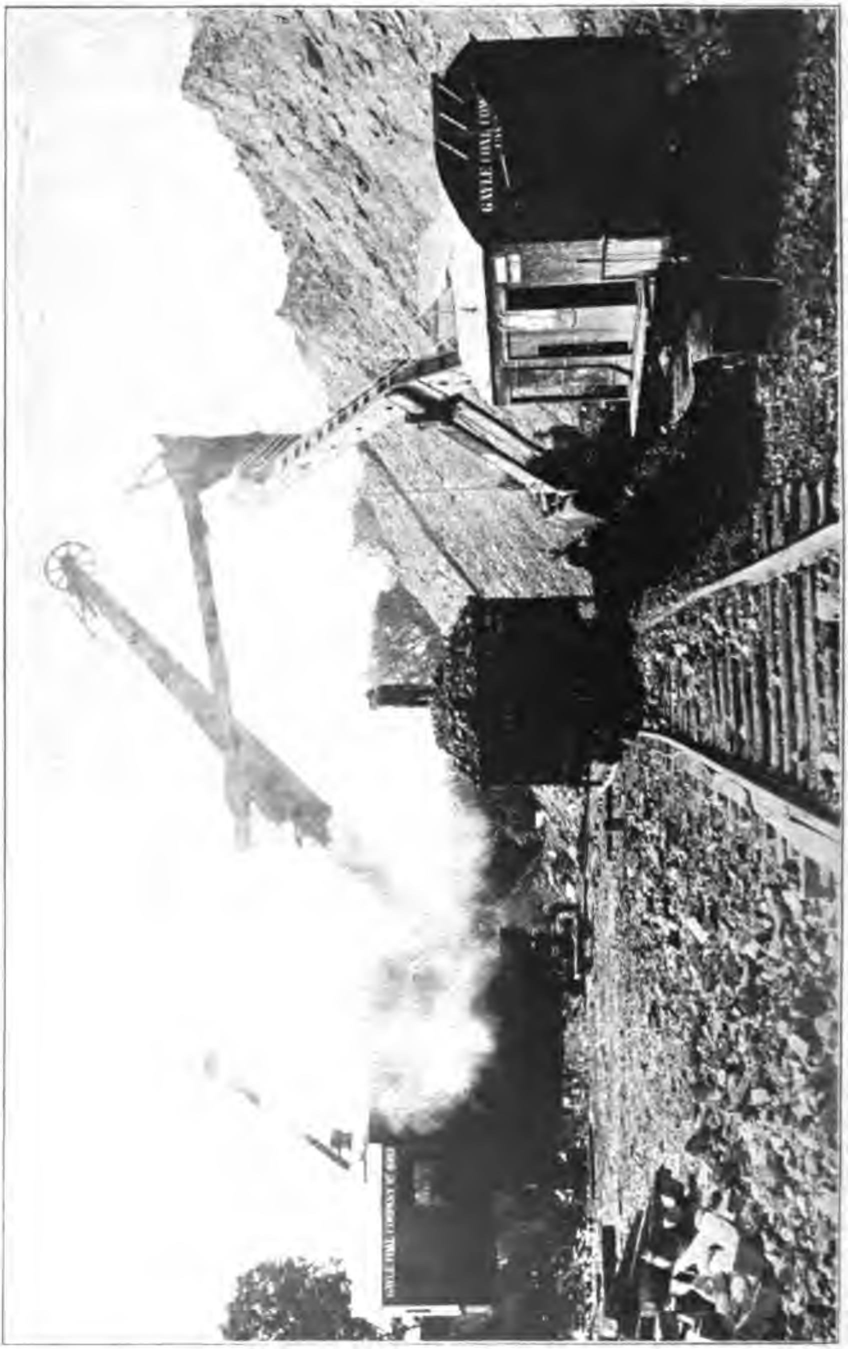
Two commercial pits are now being operated in Perry County. These are both on the crest of the fold, and hence show essentially identical conditions and character of coal. At the north pit the stripping is done with an electric shovel having a 6½-yard dipper on an 86-foot boom. The stripping shovel makes north-south cuts, working eastward across the property. A bulldozer followed by shoveling and sweeping gangs finishes the cleaning of the surface of the coal, which is then shot with a "strip special" powder. A 2-yard electric shovel (fig. 11) loads the coal into railway cars in the pit, which are hauled to the sidings to await shipment. As the coal is used as railroad fuel, it is sent out as mine run without screening. Where measured, the overburden included 9 feet of till underlain by 1 foot of shaly sandstone, 2 feet of black shale and 8 feet of very argillaceous sandstone, practically shale. On the east side of the property boulders of limestone were encountered, which represented the usual cap of the Herrin bed. These are reported to have come in above the upper sandstone.

The top coal had been removed and the base was not exposed in the following measured section:

	Thickness *Inches*
Coal, practically all bright, some calcite facings	8 6/8
Pyrite lens 8 inches long	7/8
Coal, alternately dull and bright	27
Pyrite lens 5 inches long	6/8
Coal	3
Charcoal parting	3/8
Coal, with small pyrite balls and lenses	30
Total	70 3/4

Pope County

Described on page 58.



Courtesy of Gayle Coal Company.

FIG. 11. Loading equipment at Duquoin pit, Perry County.

RANDOLPH COUNTY

Conditions in Randolph County are practically identical with those of St. Clair County to the northwest. The heavy overburden of glacial deposits prevents precise delineation of the line of outcrop of the Belleville (No. 6) coal, and the eastward dip of the Pennsylvanian strata carries the coal within short distances from the outcrop beneath too heavy an overburden of bed rock for stripping (fig. 12). From available data, however, the following townships appear to be underlain by coal at shallow depths:

T. 4 S., R. 6 W.
T. 5 S., R. 6 W.
Twps. 5 and 6 S., R. 5 W.

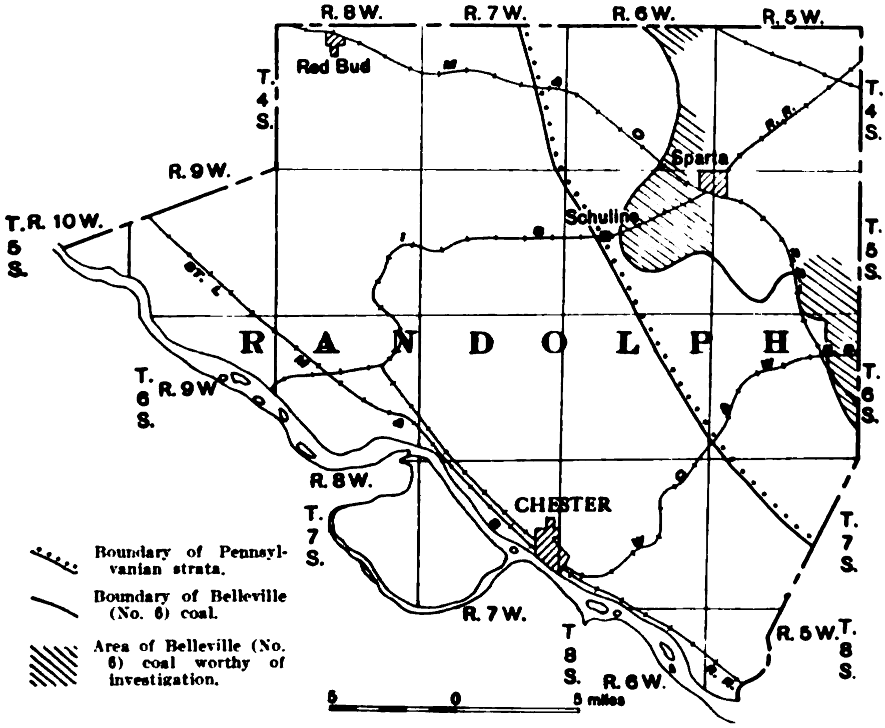


FIG. 12. Index map of Randolph County.

Some testing has been done in T. 5 S., R. 6 W., but no commercial opening has been reported.

The Belleville coal in this field is approximately 72 inches thick. The "blue band" or shale parting in the bottom third of the bed is everywhere present and the coal shows the same quality that marks it in the Belleville district.

In sections measured, the coal ranged from 22 to 26 inches in thickness. It is not clear that the coal at any point will greatly exceed 36 inches. The bed is relatively clean, and shows well developed cleat, so that it breaks into rectangular blocks which are readily handled without much breakage. Little pyrite appears in the bed itself, although the contact at the top is generally marked by a zone of mixed shale and pyrite from one to two inches thick. In places the top 2 inches is bony. Another shaly zone comes in locally about 6 inches from the bottom. The bedded impurities loosen readily from the coal, and in general cause little trouble.

The roof materials vary in different parts of the field. The immediate cover of the coal is uniformly shale, although it ranges in thickness from less than 1 inch to several feet. Where thin, it is little more than clay, but in the thicker portions it is massive and locally so gritty that it might properly be classed as sandstone. It should not, however, give any serious trouble in removal. In the upland areas, the thicker cover appears to include a limestone bed immediately over the thin clay above the coal. This limestone is as variable in thickness as it is in occurrence, appearing as a row of concretionary boulders in some places, elsewhere as a massive bed nearly 4 feet thick. It is medium to dark gray in color, finely crystalline, and contains abundant fossils. In the limited area mapped as probable strip land in Richland County, the cover is probably not greater than 35 feet in thickness. Too little is known at present of the extent of and the depth to the coal to indicate even tentatively any extensions of the area mapped. On the other hand, the topography of the adjacent region, especially to the east and west, is such that if the coal maintains an essentially horizontal attitude it may be workable by stripping methods at least as far east as the Lawrence County line, and perhaps as far west as Clay County.

Within the past two years a local pit has been operated just east of Calhoun. No attempt at extensive production is being made, although the local needs of the county are well met. The cover is removed by a steam shovel operating a 4-yard dipper on a 70-foot boom. Straight north-south cuts are planned for the shovel, the overburden being placed in the cuts from which the coal has been removed. The coal is wedged and loaded by hand, and the impurities are picked out as the loading proceeds. By this method, the product is largely lump, and but little loss through slack is sustained.

SALINE COUNTY

Conditions in regard to strip mining are much the same in Saline County as in Williamson County to the west. One important point of difference should be emphasized. The Herrin (No. 6) coal is of little consequence in Saline County, as it is generally too thin to be valuable, while the Harrisburg (No. 5) coal is thicker and of better quality.

The surface cover prevents accurate determination of the line of outcrop of either bed, and hence the lines mapped are subject to later correction. As mapped, the outcrop line of the Herrin coal may be followed across the county in an east-west line near the middle of T. 9 S., Rs. 5, 6, and 7 E. (fig. 20), and that of the Harrisburg coal lying about 125 feet lower crosses the county similarly but nearer to the boundary between 9 and 10 S. Because of the rather sharp dip and the consequent increase in thickness of cover toward the north, the belt in which the Harrisburg (No. 5) coal can be profitably stripped appears to be narrow, but drilling may show it to be considerably wider than indicated on the map (fig. 20). It is obvious that the limit of stripping coal is closely related to the rather rough topography of the area, which, if the variable dip of the coal bed is considered, may cause either enlargement or reduction of the stripping field.

The Harrisburg coal is commonly described as bright and hard. Very thin bands of glance coal alternate with somewhat thicker bands of dull coal, and charcoal layers up to 1 inch in thickness appear at intervals throughout the bed. In general, it is somewhat brighter than the Herrin coal, and is somewhat harder, but it is doubtful if physical appearance serves to distinguish coal from the two beds. The Harrisburg coal ranges from 54 inches to more than 90 inches in thickness. Inspection of the available sections fails to reveal any persistent partings like the "blue band" of the Herrin bed, although a parting of clay and pyrite near the top of the bed is not uncommon.

The immediate roof of the Harrisburg bed is in most places slaty shale, less than one foot thick, and overlain by dark gray shale which locally reaches a thickness greater than 40 feet. Commonly a limestone from 3 to 10 feet thick appears within the basal 20 feet of the gray shale, and very sandy beds come in on top of this limestone. Above the bed rock is 10 to 30 feet of yellow clay, generally without boulders. In the narrow belt mapped the total cover is thought to be less than 70 feet at the maximum.

Stripping for local needs alone has been done from time to time in this field, and it is only recently that any commercial operations have produced coal. At the pit near Ledford, southwest of Harrisburg, T. 9 S., R. 6 E., the stripping is done with a steam shovel equipped with a 6-yard dipper on an 80-foot boom (fig. 14). The strip cut is from 30 to 50 feet wide, making an irregular trench trending approximately north of west and working northward across the property. The steam shovel is followed by shovel and broom gangs. After shooting, the coal is loaded with a steam shovel having a 1¼-yard dipper into 5-ton pit cars with side gates. The cars are hauled in 10- to 15-car trips by steam locomotives. The pit cars dump the coal to a hopper, whence it is loaded to a pan conveyor by a reciprocating boom. From the conveyor, the coal passes over reciprocating screens giving four standard sizes and 2-inch screenings for shipment. Impurities are hand picked from the booms.

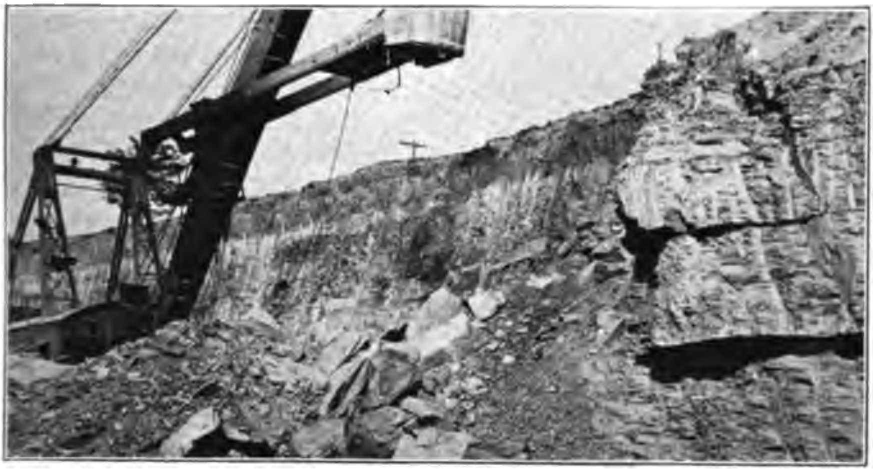


FIG. 14. Shovel making stripping cut at Ledford. Courtesy of Harrisburg Coal Mining Company.

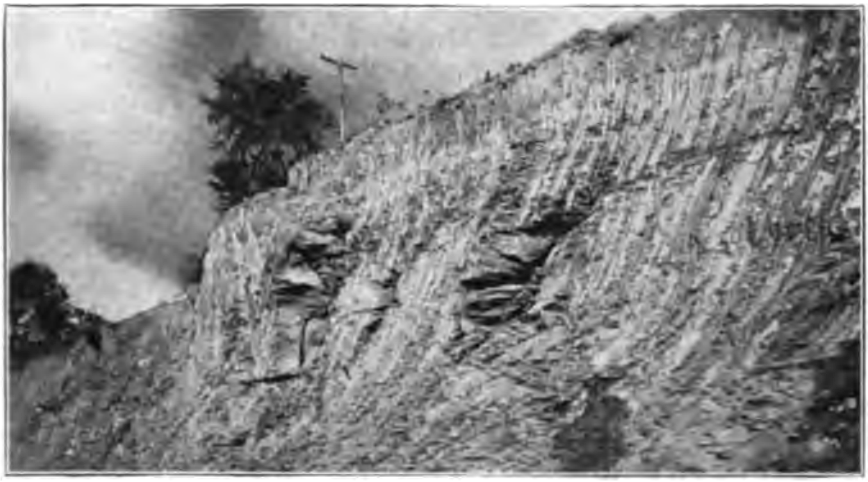


FIG. 15. Maximum overburden at the Ledford strip pit. Courtesy of Harrisburg Coal Mining Company.

The coal bed in this pit thins from a maximum of 108 inches at the east to a minimum of 72 inches at the west. The bed lies essentially flat, and is remarkably regular except for the gradual change in thickness.

The overburden handled here includes about 40 feet of gray gritty shale of rather irregular bedding with some 20 feet of yellow clay above it (fig. 15). The latter stands well when undisturbed, but is inclined to slump into the pit from the spoil-bank in rainy weather.

West of Saline County in T. 9 S., R. 4 E., and possibly in the northeast part of T. 10 S., R. 4 E., Williamson County (fig. 20) there is probably a continuation of the outcrop line of the Harrisburg coal. Here also the conditions are possibly favorable for stripping, but the extent or thickness of the coal can not be determined from available data.

Similarly east of Saline County in T. 9 S., R. 8 E., Gallatin County there is probably an extension of the strip areas, but how far the coal is thick and under thin cover is not known. Some of this field is tentatively mapped as probable strip land.

The Herrin (No. 6) coal, lying stratigraphically above the Harrisburg bed is also present in the north half of Saline County. In general, it is thinner than the Harrisburg coal in Saline County, and although available in limited areas for stripping, will probably not be commercially as important as No. 5. The few available records show this coal to be less than 5 feet thick, commonly less than 3 feet, and to dip northward so that it is too deeply buried for stripping within a short distance from the outcrop. Except for less thickness, the conditions for this bed are similar to those described for the main field in Williamson County.

SCHUYLER COUNTY

The most favorable area for stripping so far reported from Schuyler County lies in the south half of T. 2 N., R. 1 W., north and east of Rushville (fig. 16). Elsewhere, although the county is quite generally underlain by the Colchester bed, except along the drainage lines of Crooked and Sugar creeks, the only probable strip sites will be found along stream valleys near the line of outcrop.

The Rushville coal has been tentatively correlated with the Springfield (No. 5) bed of Fulton County. It ranges from 57 to 78 inches in thickness, and averages about 66 inches. No regular parting or band is reported in the bed. Although it is affected by "clay-slips" in some places, they are not large, so far as known, and do not cause much trouble in mining. The coal itself is soft, of easy and irregular fracture, and has a dull luster because of the few bands of glance coal in the bed.

The immediate roof is black shale, with a thin limestone cap. Over these is sandy shale, and in the eastern part of the field some thicker limestones have been reported in drill logs. Till of variable thickness overlies or replaces the bed rock. The maximum cover reported is 90 feet, but over large areas it is probably less than 60 feet.

Examination of the map (fig. 16) will show that several small areas in the western part of the county have been indicated as possibly worthy of testing. These are merely typical of the region in general, and no attempt has been made to include all of them. In general this coal, the Colchester bed, is too heavily covered in the upland areas to make stripping possible. Along some of the streams, however, and especially near the line of outcrop, areas of 160 acres extent may be found where the cover is less than 25 feet. It is unlikely that any commercial pits can be operated in this coal in Schuyler County under present conditions.

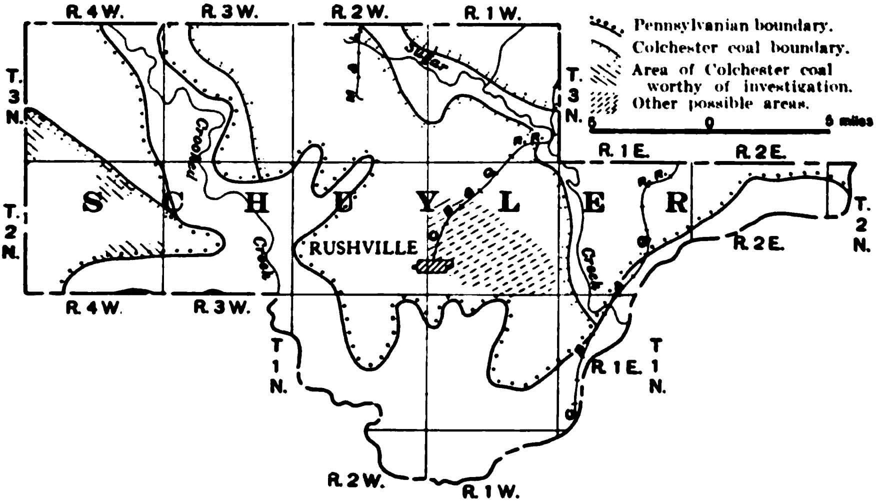


FIG. 16. Index map of Schuyler County.

ST. CLAIR COUNTY

The western limit of the Belleville (No. 6) coal passes in a southeasterly direction across St. Clair County. Because of the thick cover of unconsolidated material and the eastward dip of the Pennsylvanian beds, however, very little of the area underlain by this valuable coal can be classed as strip land. The coal appears to lie at shallow depth in two narrow fields just east of the outcrop, first, in T. 1 S., Rs. 7, 8, and 9 W., an area between Freeburg and Millstadt, and second, in T. 3 S., Rs. 6 and 7 W. in the vicinity of Marissa and Lenzburg (fig. 17). In each area, the Belleville coal ranges from 60 to 84 inches, and shows the three benches which characterize it in this part of the State. The top 12 to 24 inches is commonly the purest coal of the whole bed; the middle or thickest bench, is commonly duller than the rest and contains numerous bands of dirt, pyrite, and charcoal; the bottom bench, below the "blue band", is extremely variable in composition and ranges from 12 to 24 inches in thickness. In places it is little more than carbonaceous shale, although elsewhere it is as good as the middle bench.

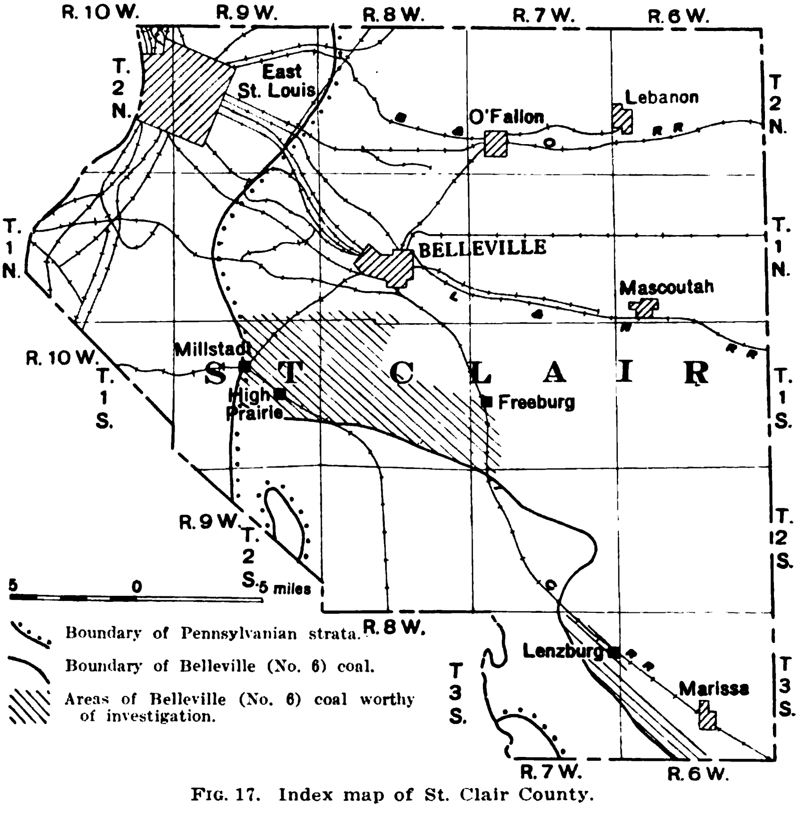


FIG. 17. Index map of St. Clair County.

Below the surficial materials, the coal is covered by bed rock of increasing thickness as the bed is traced eastward. This includes the black shale roof and the cap limestone, above which lies thick hard shale. The roof shale ranges from 8 feet to less than an inch in thickness within relatively short distances and the limestone cap shows nearly as great variation. Near the outcrop of the coal, the overburden rarely includes any bed rock above the cap limestone, but farther east the upper shale is prominent. In the vicinity of Millstadt, the cover is less than 35 feet and it is probable that other fields may be found in which similar conditions obtain.

Early in the preceding decade, a single operation in St. Clair County was producing at the rate of more than 15,000 tons annually. No information is at hand regarding the details of the methods of handling either the overburden or the coal. Within the past year, some acreage west of Freeburg has been taken up and equipment for a commercial pit may soon be installed.

VERMILION COUNTY

In no county in the State has stripping been so important as in Vermilion County. Here were worked out many of the improvements both in equipment and the method of working which have made it possible at the present time to strip coal that earlier was far too deeply buried for such recovery. Geologic reports for Vermilion County show the outcrop lines of the Danville (No. 7) and Grape Creek (No. 6) coal beds drawn in a general north-south direction through T. 20 N., R. 12 W.; T. 19 N., Rs. 11 and 12 W.; T. 18 N., R. 11 W., and T. 17 N., R. 11 W. (fig. 18). Is some places this outcrop is accurately determined; in others the overburden prevents detailed mapping. Along the main channel of Vermilion River, both coals are above drainage, but upstream above the main fork, the westward dip of the coal beds carries them well below drainage and also below too great a thickness of overburden for stripping. It is mainly along the widened river valleys that stripping is practicable, and in the thirty-five years that mechanical stripping has been practiced in this field, a large percentage of the available strip land has been worked. On this account, the Vermilion County field is of interest more for its historical background than for its probable place in the coming development of the stripping industry.

Two coal beds underlie the Vermilion County field, and each has been worked by stripping methods. The upper bed, commonly called the Danville coal and correlated as the No. 7 in the Illinois section, ranges in thickness from about 36 inches to more than 60 inches in the stripping area. The bed varies locally in thickness, especially where the bed rock cover has been removed and the glacial drift lies directly over the coal. In some places, a shale parting not unlike the "blue band" of the No. 6 coal, divides the bed into two benches. As a rule, the partings are not as persistent as in the lower bed. Pyritic masses of various sizes are especially abundant in parts of the bed. Equipment for operating and cleaning this material was installed in one plant, and during the war period the demand for sulphuric acid provided considerable profit on this by-product. Of late years, this separated material has not been marketed.

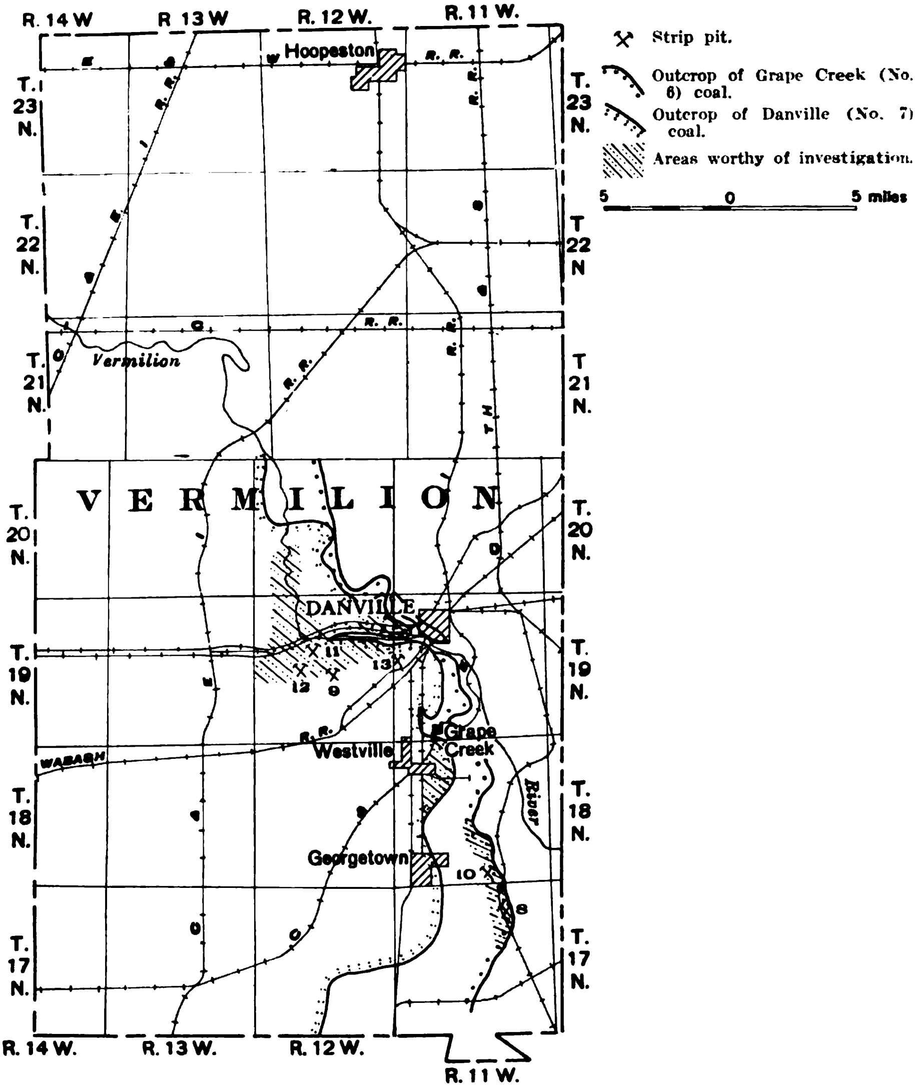


FIG. 18. Index map of Vermilion County. Figures accompanying strip pit symbols refer to mines listed in Table 1.

The roof of the Danville bed is commonly black shale of variable thickness, overlain by gray shale which in places reaches a thickness of more than 50 feet. Its thickness in the stripping field depends upon the extent of erosion that the area has undergone. Above the bed rock is the usual glacial drift of the region. Where untouched by stream erosion, this is generally too thick for removal by shovels. The stripping areas are largely restricted to the vicinity of the larger stream channels.

The Grape Creek (No. 6) coal in the probable stripping area is generally more than 72 inches thick. It commonly lies in two benches separated by the shale parting known as the "blue band", which comes somewhat below the middle of the bed. The two benches are not unlike, consisting of alternating dull and bright layers with interlaminated charcoal, dirt, and pyrite. The Grape Creek coal has in most places a smaller amount of impurities than the Danville bed.

In the stripping area, the bed rock over this coal is shale, although in the immediate vicinity of Danville there is a persistent limestone caprock somewhat above the coal. The more common shale is relatively unconsolidated, and is readily handled by the shovel.

Six commercial pits are now being operated in Vermilion County, four of them working the Danville coal, and two working the Grape Creek bed. In the westernmost of these pits, the stripping is done with a steam shovel operating a 6-yard bucket on an 80-foot boom. The coal has been stripped in a series of east-west cuts, working northward to a limit fixed by former underground mines long since abandoned. Shovel gangs finish cleaning off the coal, brooms being used only when necessary. The coal is then shot with black powder, loaded into 5-ton pit cars with a standard steam shovel using a 1½-yard dipper. The cars are hauled by 20-ton steam locomotives in trips of twelve to the foot of a long incline leading to the tipple at the top of the bluff. On account of the long steep pull, the pit cars are handled one at a time up this incline. At the tipple, most of the coal is passed over screens and picking tables, although some mine run is also marketed. Water in this pit is pumped over the spoil bank to the main drainage line of the region.

The overburden, though thinner near the river valley to the south and east, is rather uniformly about 35 to 50 feet where it is now being removed. It includes about 10 feet of surface soil and slightly bouldery clay and from 25 to 40 feet of light gray shale, fairly hard and usually well bedded. Practically no variations in character of overburden are met in this tract. The coal ranges from 5½ to 6 feet in thickness, and is essentially flat. The only interruptions of the bed are found where the shale roof and some of the coal have been removed by earlier erosion, producing a down-roll which in places cuts out all but two feet of the bed.

Another pit, also working the Danville coal bed, is operating two steam shovels, one equipped with a 3-yard dipper on a 70-foot boom, the other with a 6-yard dipper on a boom about 80 feet long. Throughout this pit, the stripping is done essentially along lines which parallel the drainage of the area, the limit of stripping is determined by the main valley walls, back of which the overburden is too great for present methods and equipment. Shovel gangs follow the stripper, and the coal is loaded out to 5-ton, side gate, pit cars with a 1½-yard steam shovel. The pit locomotives carry about fifteen cars in a trip to the foot of a long incline leading to the tipple, which is situated along the railroad track at the top of the bluff. Cars are hauled up the incline by a cable in trips of four. At the tipple, they are dumped into a hopper which feeds the coal on to an endless steel conveyor by which it is carried to the screens. On this first conveyor, the larger lumps are sledged and two pickers remove impurities. After screening, the coal again passes over picking tables before being loaded by booms to railway cars below. This tipple was equipped during the war period for separating and cleaning the pyrite which occurs rather abundantly throughout the coal bed. Since the demand for this material has lessened, it is merely separated and buried to prevent firing.

The coal in this pit ranges from 5 to 6 feet in thickness, and although it includes the many impurities of pyrite and shale characteristic of this bed, no regular partings are recognized. The overburden is extremely variable, depending on the location of the cut with reference to the valley. In much of the middle portion of the valley, there is as little as 6 feet of shale immediately overlying the coal, with perhaps no more than 12 feet of till or alluvial sands above. As the shovel approaches the main valley wall, however, the overburden changes in character and increases in thickness. At points where maximum cover is removed, the cut shows as much as 15 feet of surface material, including some bouldery clay and 35 feet of light gray shale, well bedded and rather hard.

In working the Grape Creek coal southeast of Georgetown, the overburden is handled with a steam shovel operating a 5-yard dipper on an 80-foot boom. The coal is recovered from a stream valley, and, as usual in such situations, the direction of cut is determined by the topography of the field. The shovel gang completes the cleaning of the coal, as sweeping is usually unnecessary because of the character of the overburden. The coal is loaded out with a steam shovel using a 1½-yard dipper. Pit cars of 5-ton capacity with side gates, and running on a 36-inch track are hauled out in trips of four to the tipple at the west end of the pit. The coal is dumped into a hopper, thence fed to a steel conveyor, by which it is taken to screens and picking tables. Two sizes are made in this mine; all coal passing one-inch bar screen is classed as lump and the rest as screenings. Lump coal is loaded over booms, the screenings through chutes. The overburden in this pit varies as different parts of the valley are worked, but on the average shows from 10 to 15 feet of surface material with perhaps a maximum of 25 feet of shale below. The coal bed averages about 5 feet in thickness and commonly shows some pyrite and shale partings.

WABASH COUNTY

Wabash County has never been more than a local producer of coal, for the known beds are thin or lie deeply buried. In the south central part of the county, however, a coal of moderate thickness appears to lie at shallow depth in T. 1 N., Rs. 12, 13 and 14 W., and in Tps. 1 and 2 S., Rs. 13 and 14 W.

The only coal in the county which appears to be workable by stripping methods is the thin bed known as the Friendsville coal, which has been mined in wagon pits near Friendsville, Maud, Bellmont and Keensburg. It has been reported generally at shallow depths elsewhere in this field, so that its area is fairly well known. At the north, however, the limit is not fixed, and the coal is possibly continuous with the similar bed near Calhoun in Richland County.

In Wabash County, the Friendsville coal ranges from less than 12 to more than 48 inches in thickness, and perhaps does not vary much from 36 inches over most of the area mapped (fig. 19).

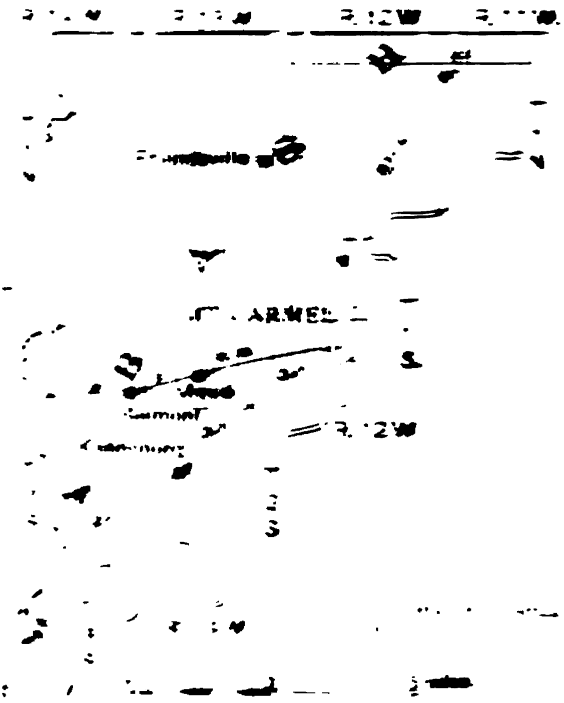
In this field, the cover ranges from less than 10 feet to more than 65 feet. It is believed that along the rather wide stream valleys of the region, considerable tracts will be found in which the coal lies at less than 35 feet below the surface.

The roof of the coal is commonly gray shale but where the bed rock cover is thick, the shale may be topped by sandstone. Locally, as reported in a few tests, the coal is accompanied by a limestone roof and this, too, is in places overlain by sandstone. In these variations, the Friendsville coal closely resembles the Calhoun bed which is mined a few miles to the northwest.

So far as has been reported, this bed has not been stripped, and no analyses are at hand to indicate its composition. From early reports, the coal appears rather high in impurities, so that the yield of ash is large. It burns rather freely, but does not coke.

WARREN COUNTY

Warren County shows but little territory which appears to be valuable as strip coal property. In general, the coals of the county are


R. 12 W
ARMEL
R. 12 W

sandy in the upper part than below, commonly grading laterally into sandstone. It is not believed that this stratum will seriously interfere with stripping operations. In the area indicated on figure 9, the surface material seems to be from 5 to 55 feet thick, but it is recognized that this maximum will be exceeded locally.

The lower coal, which is present in at least the eastern part of T. 9 N., R. 2 W. is about 40 inches thick, but is relatively soft and notably laminated with prominent bright and dull bands. A bony or shale parting near the middle is usually present, and the lower bench is softer than the top. Facings of calcite, gypsum and pyrite are so common in exposures now known that the ash and sulphur content is generally high. It is not improbable that, when opened farther from the outcrop, the impurities will be of less importance, a feature which should be carefully noted in any tests for commercial operations. The overburden, obviously greater than that of the Colchester bed, is essentially the same as that noted for the upper bed, with the additional bed rock which normally intervenes between the two coals. This interval at the maximum includes about 30 feet of shale below the Colchester bed, and from 2 to 8 feet of limestone coming between that shale and the roof clod of the lower coal bed. It is not probable that there are any extensive areas in which the lower bed can be stripped.

WAYNE COUNTY

Described on page 57.

WILL COUNTY

Described on page 26.

WILLIAMSON COUNTY

Williamson County includes between thirty and forty miles of the outcrop line of the Herrin (No. 6) coal, and an unknown amount of the outcrop line of lower beds such as the Harrisburg (No. 5) and the Murphysboro (No. 2) coals. Since the areas in which these lower beds may perhaps be stripped can not be defined on present data, this report will deal with the Herrin bed only. Some mention of the Harrisburg coal was made in connection with the discussion of that bed in Saline County.

Because of the relatively steep northward dip of the Pennsylvanian beds in this part of the State, the stripping area for the Herrin coal is limited to a narrow belt just north of the outcrop line. The cover of glacial drift in this county, as elsewhere in the coal fields of Illinois, renders it difficult to determine the limit of any coal bed accurately. Particularly in the area between Herrin and Crab Orchard Creek valley to the south are the relations indefinite.

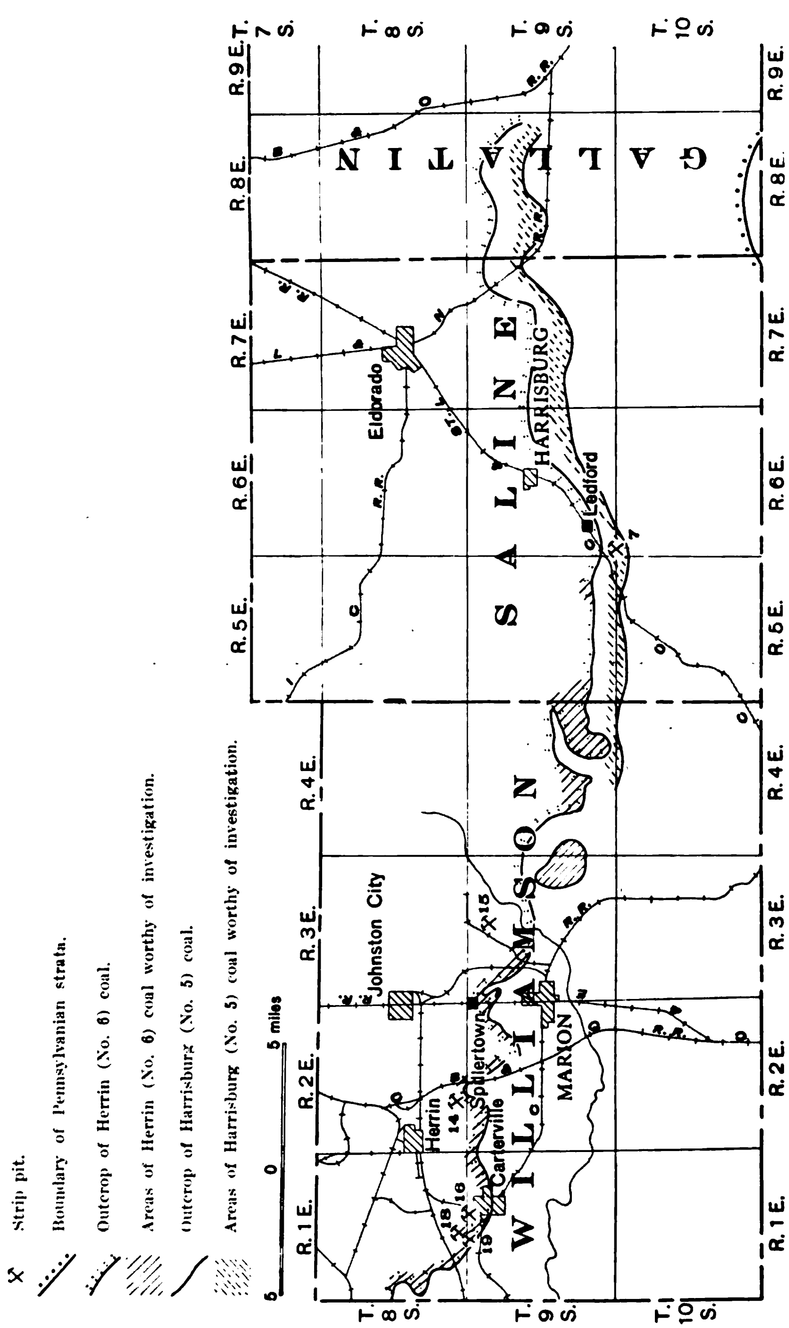


FIG. 20. Index map of Williamson, Saline and western Gallatin counties. Figures accompanying strip pit symbols refer to mines listed in Table 1.

With the above modification, the following townships may be considered as including the outcrop of the No. 6 coal in such relations of thickness and cover as to be worth testing for stripping purposes: T. 8 S., R. 1 E.; and T. 9 S., Rs. 1, 2, 3, and 4 E.

Throughout practically all of this field, the coal is 72 inches or more in thickness, although in some pits it averages as much as 84 inches. As elsewhere, on account of pre-glacial erosion, the coal is thinner and shows greater variation in thickness near the outcrop than farther back. The following descriptions of this coal now mined so extensively underground in the northern part of this county and in Franklin and Jefferson counties is generally applicable to this field.[1]

"The coal is shining black, commonly banded, and on close inspection appears laminated with alternating bright and dull lines. A 'blue band', or dirt band, found almost everywhere 18 to 30 inches above the floor, generally consists of bone or shaly coal or of gray shale. Its thickness varies from one-half to 2½ inches with an average of about 1⅔ inches.

"A clean persistent parting of mother coal lies 14 to 24 inches below the top of the bed and a second parting generally appears 5 to 8 inches down. Above the upper parting the coal is in layers 3 to 6 inches thick, with partings of mother coal between them. Local lenses of mother coal, 6 inches to 5 feet in length and 1 to 4 inches thick, are common in the upper third of the bed. Small pyrite lenses and streaks of bone, a few inches to a foot or more in length and one-fourth to 1 inch in thickness are found here and there in the middle portion of the bed, a short distance above the 'blue band'. In the middle and lower parts of the bed the lamination is less distinct but the bedding is still evident."

The cover of the Herrin (No. 6) coal near the line of outcrop is similar to that described for Jackson County on the west. In the area mapped for testing (fig. 20), the cover is believed to be less than 70 feet thick. The glacial drift, including some boulder clay but more commonly fine clay without stones larger then pebbles, ranges from about 5 to 25 feet in thickness. Near the margin of the coal bed the cover is about half of surficial and half of bed rock materials. As the deeper part of the field is entered, the increased thickness of cover includes a greater proportion of bed rock.

The immediate cover of the coal is normally 3 feet of black shale, slaty in places. Above this is the cap limestone, ranging from a thin stratum of boulders to a massive bed more than 5 feet thick. The limestone is overlain by another bed of shale more or less sandy and grading to sandstone in places. In some pits, clay shale comes in between the coal and the slaty black shale. Near Spillertown, T. 9 S., R. 2 E., this gray shale is commonly in the form of lenses, but elsewhere, as near Carterville, T. 9 S., R. 1 E., it is a thick massive bed, and no other strata appear over the coal.

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[1] Shaw, E. W., and Savage, T. E., U. S. Geol. Survey Geol. Atlas, Murphysboro-Herrin Folio (No. 185), p. 14, 1912.

These several beds above the coal vary considerably from place to place, so that no standard cover can be described. Where thin, the overburden may include some 15 feet of glacial clay with an equal thickness of gray shale or of limestone and slate above the coal. Where the total cover is thicker, the glacial drift may be no heavier, but the additional overburden includes greater thicknesses of limestone and of overlying gray shale. It is believed that only rarely will areas be found in which cover is of such character as to be too difficult to remove with modern stripping equipment.

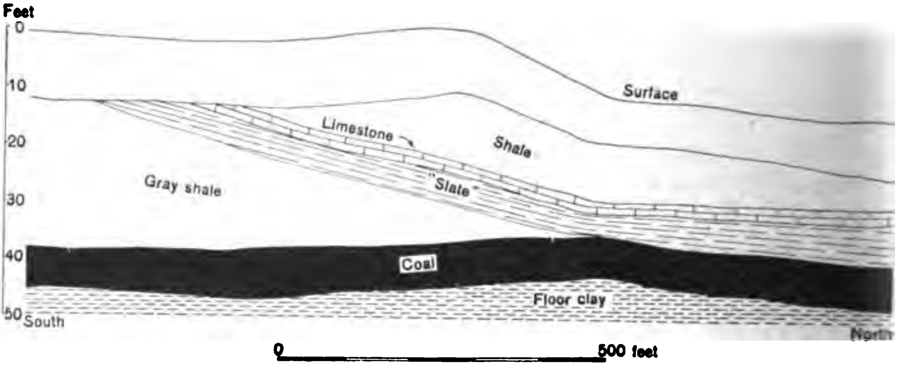

FIG. 21. Diagrammatic section of overburden in a Williamson County pit.

Stripping has been practiced for many years in this county so that equipment and mining methods vary from pit to pit. At one of the larger pits southeast of Herrin, the stripping shovel makes a straight north-south cut working westward across the property. The surface of the coal is well cleaned with shovel and broom, so that after shooting the coal can be loaded directly to the railway cars for shipment. No screening equipment has been installed at this pit since mine run only is shipped.

The coal at this pit ranges from 72 inches to 102 inches in thickness, except where part of the bed has been removed by erosion. The bed dips gently northward, but shows local rolls as much as 5 feet high. Figure 21 shows the relative positions of coal, shale, and limestone, as exposed at the time of examination of this pit. It will be noted that the shale bed just over the coal thickens to the south. Where the pit was opened, no other bed rock appeared over the coal. The coal itself has shown but little variation in character or thickness with the change in the overburden. Where measured, the bed was 8 feet thick and showed few partings except the regular "blue band" of shale about 2 feet above the floor clay.

Whatever water accumulates at the bottom of the pit is pumped over the uncut bank into the regular drainage channel of the area.

South of this pit is another which has been worked with varying degrees of success for several years. At the present time, the stripping is done by a steam shovel operating an 80-foot boom which carries a 6-yard dipper on a 58-foot dipper-stick. The plan of operations has been changed from time to time as various factors have necessitated modification of the original plan. Recently the coal has been stripped in a circular belt, the first cuts being as far from the outcrop as present equipment seemed to permit. The surface of the coal is cleaned by means of team and scraper, followed by shovel gangs. The coal is then shot with black powder and loaded directly into railway cars. With this equipment coal is loaded out at the rate of 2000 tons per 8-hour shift, the stripping shovel working three shifts.

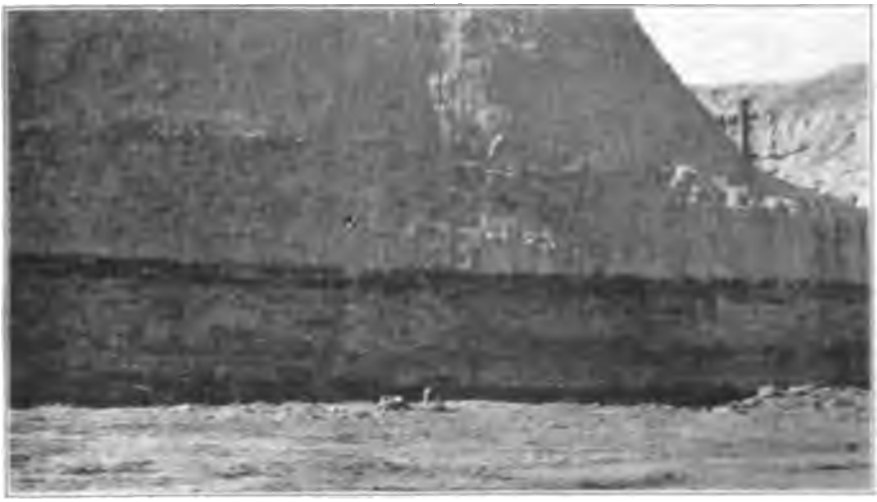

FIG 22. Coal and overburden at Spillertown pit, T. 9 S., R. 3 E., Williamson County

The coal bed is interrupted in this pit by a small vertical fault which trends about north 25° west and is crossed at both ends of the semi-circular pit. This is of slight consequence, except as it slows up the loading and makes it necessary for the loading shovel to spend some time cleaning up the mixed coal and shale at the fault zone. Some shifting of the track grade is obviously necessitated by the fault also.

In the Spillertown area, T. 9 S., R. 2 E., no large pits are now being worked, but several local pits are usually in operation. These commonly work on as little as ten acres, so that there may be three or four pits on a single forty-acre tract. In the main, these are wholly hand worked, the mule and hand scraper followed by sweepers or not, as the market may demand. Most of the surface dirt is cleaned off but the elimination of the hard roof shale is not as thorough. Water is usually taken care of by gasoline driven pumps.

The coal is not worked far down the slight northeast dip, since the stripping equipment does not permit handling any great thickness of overburden economically. The exposures examined show coal from 6 to 8 feet thick, about 3 feet of black fissile shale with highly weathered limestone nearly 10 feet thick, and from 5 to 15 feet of surface clay on top. Figure 22 shows the general appearance of the pits in which the bed rock cover is slight and includes no limestone.

OTHER COUNTIES

GENERAL STATEMENT

As stated in the general discussion earlier in this report, some of those counties lying outside the main producing fields of the State are known to contain more or less extensive deposits of thin coal at depths which in general are slight enough to permit stripping. These beds have been worked in a small way for a great many years, but little or no systematic drilling has been reported so that their actual extent is not known. Commercial operations have not been started in any of these counties, nor does it seem likely that any will be in the near future. On the other hand, some of these deposits may be of value in meeting the present local needs of communities commercially less accessible to present coal production, and certainly will be important in the future when the thicker coal beds are worked out.

The coal immediately below the surface material throughout these minor fields is uniformly thin, ranging from a few inches to a little more than 3 feet. In general, the deposits are less than 24 inches thick, but further drilling may show greater average thickness in places. The beds are essentially flat lying when large areas are considered, but within a given township or even a single square mile, considerable difference in elevation may be noted. The coal lies in a series of irregularly shaped, nearly discontinuous basins, so that several distinct fields may be found within a single county. In places the coal has been found to be of excellent quality. Elsewhere, even within a short distance, it has been found to vary from good to very poor grade, with abundant partings of shale or pyrite. In other words, these deposits exhibit the variation in both chemical and physical properties which are to be expected in coals of local deposition in small swamps where conditions were not uniform either over large areas or during long periods of time.

Comparable to variations in the coal bed are the differences in roof conditions. Shale is the most common roof for these beds of thin coal, but it may be sandy, or slaty, or soft and massive. Locally, the roof is sandstone or in a few places limestone.

EFFINGHAM AND CLAY COUNTIES

A coal which Worthen called No. 16 of the general coal section, lies beneath relatively light cover in the southwestern portion of Effingham County. It has been reported 36 inches thick, but where measured, proved to be less than 24 inches. The bed dips eastward so that it is too deep for stripping a short distance from its outcrop. The overburden is variable in character, locally including calcareous black shale. In places the coal is overlain by a 4-foot limestone and loose drift. Probably the only stripping areas will be found near the drainage lines. Northwestern Clay County may include an extension of this field.

MARION AND JEFFERSON COUNTIES

Thin coal underlies practically all of Marion County, and all but the southwest part of Jefferson County, ranging in thickness from a few inches to 2 feet. Worthen reported coal at nearly forty places in Marion County alone, and stated that the quality was "in most instances very fair." With but few exceptions, he referred all these discoveries to the same coal bed. If this is the case, the deposition of coal seems to have been rather more uniform here than in Effingham and Clay counties to the northeast. The overburden includes black sheeted shale with limestone overlying it in places. Elsewhere, the black shale grades upward into softer shale, capped by sandstone. In Jefferson County, the bed rarely includes more than 18 inches of good coal, the rest being pyritic and bony. In places the bed is split by a shale parting, which locally becomes too thick to permit mining the coal.

WAYNE AND EDWARDS COUNTIES

Only a small part of Wayne and Edwards counties contains coal of any thickness suitable for stripping. In the northeast portion of

Wayne and the adjoining part of Edwards County, a coal ranging from 1 to 2 feet in thickness lies relatively near the surface, but it is commonly too deeply buried to be stripped. The bed rock overburden includes a few feet of shale with sandstone above. The surficial deposits are usually less than 15 feet in the interior of the counties, but somewhat thicker toward the east margin of Edwards County along Bonpas Creek and the Wabash. In southeastern Edwards County, a coal bed ranging from 30 to 36 inches in thickness lies at less than 40 feet beneath several small areas. The coal is reported to be hard, of splinty or semi-block grade, and is probably to be correlated with some of the beds across the Wabash in Indiana. It was tentatively regarded by Worthen as identical with his No. 13 of the Illinois section.

JOHNSON AND POPE COUNTIES

Both Johnson and Pope counties lie at the south end of the Illinois coal field, and do not appear to contain coal deposits that are especially valuable for stripping purposes, but as stripping has been done in places in them, a brief discussion is included in this report.

Coal has been stripped in sec. 32, T. 11 S., R. 3 E. and secs. 3, 19 and 32 of T. 11 S., R. 4 E., all in Johnson County. The areas suitable for stripping are limited to the rather sharply incised valleys. The coal ranges from 18 to 36 inches in thickness, and commonly lies beneath a sandstone roof. Only limited thicknesses of this rock can be removed profitably in the local stripping operations afforded by this thin coal.

In Pope County, stripping coal is known in secs. 14 and 32, T. 12 S., R. 6 E. Here, the coal outcrops along streams, and the cover is too thick for stripping, except close to the channels. The coal is about 2 feet thick, and is usually overlain by from 5 to 12 feet of dark gray shale. Where the bed rock is heavier, the cover includes several feet of sandstone.

Both of these coals are thought to lie low enough in the general coal section of the Illinois field to be at or below the horizon of the No. 1 coal.

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